

**Special Report 65**

**U.S. Army Research Institute  
Program in Basic Research  
FY 2005 and FY 2006**



**Basic Research Unit  
Paul A. Gade, Chief**

**November 2007**

Approved for public release; distribution is unlimited.

**20080107208**

**U.S. Army Research Institute  
for the Behavioral and Social Sciences**

**A Directorate of the Department of the Army  
Deputy Chief of Staff, G1**

**Authorized and approved for distribution:**



**MICHELLE SAMS, Ph.D.  
Director**

---

**NOTICES**

**DISTRIBUTION:** Primary distribution of this Special Report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, Attn: DAPC-ARI-MS, 2511 Jefferson Davis Highway, Arlington, Virginia 22202-3926.

**FINAL DISPOSITION:** This Special Report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

**NOTE:** The findings in this Special Report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.



## REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) November 2007			2. REPORT TYPE Final			3. DATES COVERED (from... to) October 2004 – September 2006		
TITLE AND SUBTITLE U.S. Army Research Institute Program in Basic Research FY 2005 and FY 2006						5a. CONTRACT OR GRANT NUMBER		
						5b. PROGRAM ELEMENT NUMBER 611102A		
6. AUTHOR(S) Basic Research Unit						5c. PROJECT NUMBER B74F		
						5d. TASK NUMBER		
						5e. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U. S. Army Research Institute for the Behavioral & Social Sciences 2511 Jefferson Davis Highway Arlington, VA 22202-3926						8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Institute for the Behavioral & Social Sciences 2511 Jefferson Davis Highway Arlington, VA 22202-3926						10. MONITOR ACRONYM ARI		
						11. MONITOR REPORT NUMBER Special Report 65		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.								
13. SUPPLEMENTARY NOTES Subject Matter POC: Dr. Paul A. Gade								
14. ABSTRACT ( <i>Maximum 200 words</i> ):  This document contains detailed summaries for each of the U.S. Army Research Institute's basic research contracts for the fiscal years 2005-2006. These summaries are grouped according to three Basic Research Office program objectives: Providing fundamental knowledge to improve training in complex environments; providing fundamental knowledge to improving leader and team performance; and providing fundamental knowledge for identifying and measuring the attributes and skills that are critical to Soldier recruiting, assignment, performance, and retention in the transforming Army. In addition to summarizing what was done or is being done, each summary also describes the contributions of that research effort to basic behavioral science and suggests how the findings might benefit the Army and other military services.								
15. SUBJECT TERMS Training, leadership, team performance, recruitment, assessment, performance evaluation, retention, adaptability, motivation, social networks, work behavior								
SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT  Unlimited		20. NUMBER OF PAGES  112		21. RESPONSIBLE PERSON  Ellen Kinzer Technical Publication Specialist 703-602-8047	
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified						

Standard Form 298

U.S. ARMY RESEARCH INSTITUTE PROGRAM IN BASIC RESEARCH  
FY 2005 AND FY 2006

CONTENTS

	Page
THE BASIC RESEARCH PROGRAM: IDENTIFYING NEW AND PROMISING TECHNOLOGIES .....	1
RESEARCH OBJECTIVE 1: PROVIDE FUNDAMENTAL KNOWLEDGE TO IMPROVE TRAINING IN COMPLEX ENVIRONMENTS .....	4
Factors Influencing the Design and Conduct of Effective Technology-Delivered Instruction <i>Joanne Davis, Annette Towler, &amp; Kurt Kraiger</i> .....	5
Training for Efficient, Durable, and Flexible Performance in the Military <i>Alice F. Healy &amp; Lyle E. Bourne, Jr.</i> .....	13
Understanding Aspects of Individual and Collaborative Skill Acquisition in Face-to-Face and Distance Training Situations <i>Adrienne Lee, Douglas Gillan, &amp; Nancy Cooke</i> .....	19
The Integration of Implicit and Explicit Knowledge in Skill Learning <i>Ron Sun &amp; Robert Mathews</i> .....	25
RESEARCH OBJECTIVE 2: PROVIDE FUNDAMENTAL KNOWLEDGE FOR IMPROVING LEADER AND TEAM PERFORMANCE .....	30
Leadership: Enhancing Team Adaptability in Dynamic Settings <i>Katherine J. Klein, Steve W.J. Kozlowski, &amp; Yan Xiao</i> .....	31
Self-Initiated Self-Development of Leadership Capabilities: Toward Establishing the Validity of Key Motivational Constructs and Assessment Tools <i>Todd J. Maurer</i> .....	35
Identifying Individual Attributes and Learning Principles that Foster Adaptive Performance and Promote Rapid Adaptability Skill Acquisition through Multiple Modes of Development <i>Stephen J. Zaccaro</i> .....	41
RESEARCH OBJECTIVE 3: PROVIDE FUNDAMENTAL KNOWLEDGE FOR IDENTIFYING, ASSESSING, AND ASSIGNING QUALITY PERSONNEL FOR THE EVOLVING ARMY .....	46



## CONTENTS (continued)

---

An Interactionalist Analysis of Soldier Retention Across Career Stages and Time <i>Gilad Chen &amp; Robert Ployhart</i> .....	47
Measuring Average Speed of Numerical Reasoning <i>Mark L. Davison &amp; Robert Semmes</i> .....	51
Modeling the Strategic Role of Basic Emotions with Cellular Automata <i>Craig DeLancey</i> .....	56
A Valid, Culture-Fair Test of Intelligence <i>Joseph Fagan</i> .....	63
Testing a Theory of the Determinants of Individual Job Performance for United States Army Junior Commissioned Officers <i>Jeff W. Johnson</i> .....	68
Goal-Driven Perception and Cognition in Complex Social Environments <i>Douglas T. Kenrick &amp; Steven L. Neuberg</i> .....	74
An Integration of Motivation Theories <i>Avraham N. Kluger</i> .....	79
Comprehension and Memory of Spatial and Temporal Event Components <i>Gabriel A. Radvansky</i> .....	83
Social Structures Affecting Army Performance <i>David R. Segal &amp; Mady Wechsler Segal</i> .....	88
Social Structures, Social Systems and Social Networks <i>David R. Segal, Mady Wechsler Segal, &amp; Meyer Kestnbaum</i> .....	93
Construct Validating Aspects of the Theory of Successful Intelligence Via a Test Battery for Measuring Mental Flexibility <i>Robert J. Sternberg &amp; Cynthia Matthew</i> .....	98
Temporal Investigations into the Relationships Between Affect and Discretionary Work Behaviors <i>Howard M. Weiss &amp; Reeshad S. Dalal</i> .....	104

## THE BASIC RESEARCH PROGRAM: IDENTIFYING NEW AND PROMISING TECHNOLOGIES

The Basic Research Unit (BRU) research program focuses on providing the basic research underpinnings for the personnel, leader development, and training requirements of the future. This program is a critical link between the world of behavioral science and the military community. Searching out and advancing the state-of-the-art methods, theories, and findings in behavioral science; encouraging projects most likely to contribute generalizable scientific principles and new knowledge; and supporting those efforts that have potential military relevance and likelihood of leading to applied behavioral technology are BRU's key research goals.

Universities conduct most of the basic research in the program. BRU maintains close contact with other basic behavioral science research organizations as well as with ARI's applied researchers, other relevant agencies within the Army, and other military services. These contacts help to define issues that require fundamental research and facilitate the transition of basic research results to applied programs for eventual use by the operational Army.

In BRU's contract programs, a Broad Agency Announcement (BAA) is issued each year to solicit both concept papers and formal proposals relating to the announced program research areas. In a given year, the BAA highlights the research objectives of special interest and provides an open call for proposals.

On the following pages, the reader will find summaries of current and recently completed BRU contracts, which began between 2001 and 2005. There are three current BRU program objectives, each of which is discussed in detail below. These objectives

1. To provide fundamental knowledge to improve training in complex environments;
2. To provide fundamental knowledge to improve leader and team performance; and
3. To provide fundamental knowledge for identifying, assessing, and assigning quality personnel in the evolving Army.

### **Training in Complex Environments**

Basic research in this area focuses on developing concepts and methods for training complex tasks and for sustaining complex task performance. Assessing the cognitive impact of technology requirements arising from digital, semi-automated, and robotic systems on training requirements is also part of this process. One of the efforts in this area seeks to find conditions that simultaneously optimize learning, memory, and transfer of training. We seek to identify unique training principles and methods for improving interpersonal skills and team adaptability and performance. The expected outcome is applied research testing the principles and methods produced in this work package in Army training environments. The models and theories produced should be useful in accounting for individual differences in training and facilitating practical, individualized, adaptive training methods. Another effort, for example, centers on the characteristics of learners and the training environment that lead to either facilitative or inhibiting effects of seductive details embedded within the training materials, while another



addresses team learning from a distance under a variety of contexts. These advances will translate into improved training methods in a wide range of tasks.

### **Improving Leader and Team Performance**

Commensurate with the requirements for rapidly developing adaptable, flexible leaders, the basic research program in improving leader performance is directed toward providing concepts and methods for accelerating leader development and understanding and developing leader adaptability and flexibility in a manner that can be tested in the applied environment. One of our efforts is focused on developing both adaptive leaders and teams through formal instruction, developmental work assignments, and self-development. We are also committed to discovering and testing the basic cognitive principles that underlie effective leader-team performance. Another effort examines predictors of adaptive performance and the development of team leadership behaviors under the stress of performing in a metropolitan hospital shock trauma center and in the laboratory. We anticipate that results from this research will make an important contribution to understanding and improving organizational effectiveness.

### **Quality Personnel for the Evolving Army**

Identifying and measuring the aptitudes and skills that are unique to the human performance requirements of military service is a major theme of this basic research effort. As part of this process, we seek to devise methods that assess mental flexibility and adaptability, describe how these attributes develop, and measure their contribution to performance and job tenure. For example, one of our efforts seeks new ways to conceptualize and assess individual mental flexibility since mental flexibility plays a critical role in the successful application of the mental processes needed for adapting to, selecting, and shaping the environment in novel situations. Exploring the sociological and psychological factors that could influence recruitment, retention, and performance is part of the work in this area as well. Another effort is concerned with developing a valid, culture-fair test of intelligence that could be applied in selection and placement. Applied research that builds the understanding of the cognitive processes entailed in flexible thinking can be used to identify those who are flexible, adaptable thinkers and to develop these skills through effective instructional programs that facilitate the use of flexible thinking strategies in a variety of contexts.

This document provides a listing and brief synopsis of ongoing and recently completed research efforts. Project listings are organized into the three aforementioned research objectives. It is important to note, however, that basic research is but one of many programs for which BRU has responsibility.

Other programs in BRU include:

- Small Business Innovative Research (SBIR) Program;
- Small Business Technology Transfer (STTR) Program;
- International Behavioral Science and Technology Watch;
- Graduate student apprenticeship program – the Consortium Research Fellows Program with the Consortium of Metropolitan Washington Universities; and

- Outreach efforts to Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs), and research support in behavioral science for the U.S. Military Academy.

Additional information about reports from these research efforts is available upon request.

Paul A. Gade, Chief,  
Basic Research Unit

Tiffany M. Bludau, Consortium Fellow,  
Basic Research Unit



**BRU RESEARCH OBJECTIVE #1: PROVIDE  
FUNDAMENTAL KNOWLEDGE TO IMPROVE TRAINING  
IN COMPLEX ENVIRONMENTS**

Research under this objective develops concepts and methods for training complex tasks and sustaining complex task performance. The focus is on understanding the cognitive impact of Future Force technology on training requirements, the impact of voluminous multi-modal data on performance, and developing methods for improving cognitive skills.

## **Factors Influencing the Design and Conduct of Effective Technology-Delivered Instruction**

**Contract #:** DASW01-04-K-0002  
**Institution:** The University of Tulsa  
Illinois Institute of Technology

**Contract Dates:** 03/01/2004 to 02/28/2006  
**PI:** Joanne Davis (TU)  
**Co-PI:** Annette Towler (IIT) & Kurt  
Kreiger (TU)  
**Liaisons:** Scott Graham, IFRU;  
Jim Belanich, BRU

**Problem(s)/Research Question(s)** – This project examined the effect of “seductive details” on training. Seductive details refer to entertaining and interesting information inserted into training material that is tangential to the main theme of the topic. While previous research has shown that the use of seductive details and on-screen text hinders learning in computer-based training environment, our research shows that these factors at times have no effect or a positive effect on learning. Our research centers on characteristics of learners and the learning environment that lead to either facilitative or inhibiting effects of seductive details.

**Technical Barrier(s)** – Previous research establishing the seductive detail effect has used a limited set of training materials, has focused exclusively on declarative knowledge and has not adequately distinguished seductive details that are independent of or dependent of the primary training content. Little is known about the effects of prior knowledge of course content or trainees’ learning styles. Finally, preliminary research suggests that seductive details are most likely to have an effect when learners approach their limits for cognitive load (how much information they can process at once), and these limits may vary from learner to learner.

**Significance/Impact for Basic Research** – The results will allow us to assess the extent to which training design characteristics impair both trainees’ recollection of the facts and principles taught in training and their ability to perform the skills that were taught. In the long-term, this research will enable the military to design more effective computer-based training.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- Basic and applied research on learning and instructional principles;
- Instructional design for computer-based or Web-based training; and
- Game-based training; determining whether details related to game fidelity detract from learning in game/simulation environments.

### **Overview**

One common strategy for enhancing any type of training is to make the content as interesting as possible. Intuitively, these strategies should increase intrinsic motivation in learners, resulting in greater appreciation for the material and greater persistence in learning environments. Obviously, interesting information that is central to the main topic is useful and can facilitate trainees’ learning. However, trainers or instructional designers tend to include interesting information that is unrelated to the central theme to spice up mundane information. This phenomenon is called the “seductive details effect” and refers to essentially “highly



interesting and entertaining information that is only tangentially related to the topic but is irrelevant to the author's intended theme" (Harp & Mayer, 1998, p. 1). Instructional material can be seductive through inclusion of illustrations or text that is interesting and entertaining but tangential to the topic (e.g., adding a picture of a professional football team to a training module on teamwork).

Although one could argue that the inclusion of seductive details increases trainees' emotional interest in the topic, there is evidence suggesting that the inclusion of this material disrupts trainees' concentration on the main themes of the material (Harp & Mayer, 1998; Mayer, Heiser, & Lonn, 2001). Thus, trainees learn less in courses where seductive details are included along with the presentation of material relevant to the topic of the course.

Previous seductive details research has focused exclusively on declarative knowledge (i.e., knowledge of the facts and principles taught in training), and most studies have used only a single set of instructional materials (e.g., Harp & Mayer, 1997; 1998; Mayer et al., 2001). In previous research described, we found that seductive details had no effect on recall but had a beneficial effect on transfer.

### **Research Approach – Study 1**

Ninety students from two universities participated in a 10 minute computer-based training course. Participants ranged from 18-29 years of age with an average age of 21 years. The course demonstrated several functions in Excel that could be used to select a city to live in based on the city's average rainfall and temperature. Participants are randomly assigned to one of four experimental conditions: (1) training includes both seductive details and on-screen text, (2) training includes seductive details but not on-screen text, (3) training includes on-screen text but not seductive details, (4) training did not include seductive details or on-screen text. On-screen text summarizes key points covered in training, while seductive details included interesting facts about the data used in training such as "Tree crickets are called the poor man's thermometer because temperature directly affects their rate of activity. Listen for a cricket and count the number of chirps it makes in fifteen seconds. Add 37. The sum will be the Fahrenheit temperature (almost exactly!)."

### **Accomplishments – Study 1**

Use of Excel prior to training accounted for a significant 8% of the variance in procedural knowledge exam scores. However, seductive details and text-summaries did not account for a significant portion of the variance in declarative knowledge ( $R^2 = .003$ ,  $p > .05$ ), procedural knowledge ( $R^2 = .029$ ,  $p > .05$ ), or training reactions ( $R^2 = .035$ ,  $p > .05$ ), after controlling for previous experience with Excel. Thus, including seductive details and/or text-summaries did not affect training reactions or how much trainees learned, contrary to the hypotheses.

Seductive details and on-screen text interacted with trainees' learning styles. Including on-screen text greatly decreased performance for trainees with an auditory learning style and slightly decreased performance for trainees without an auditory learning style (see Figure 1). This effect occurred for both declarative and procedural knowledge learning outcomes. Also,

including seductive details greatly decreased performance on the procedural knowledge exam for trainees with a tactile learning style and slightly decreased performance for trainees without a tactile learning style (see Figure 2).

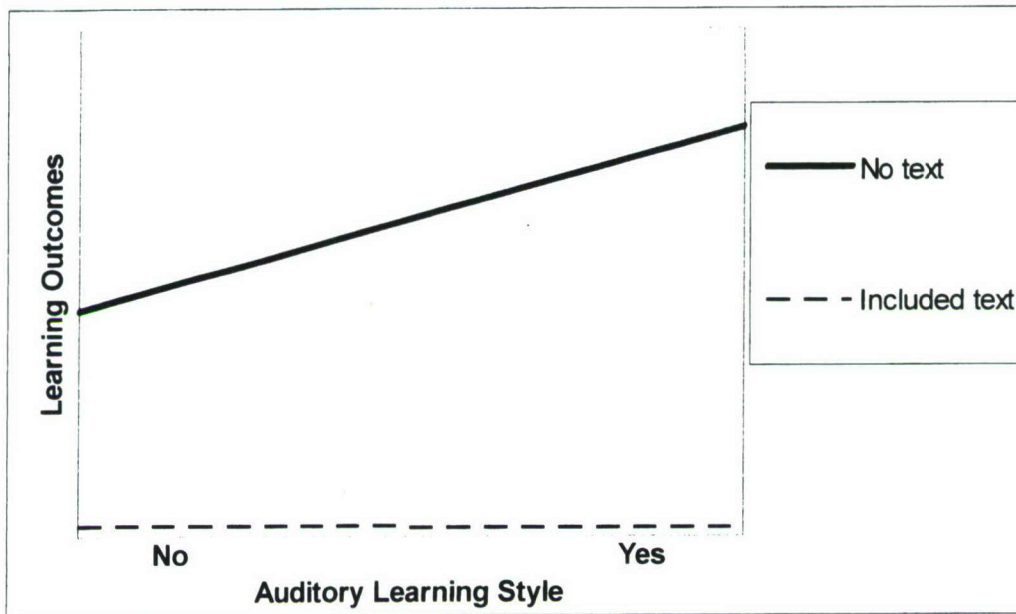


Figure 1. Interaction between text-summaries and auditory learning style when predicting declarative and procedural knowledge test scores.

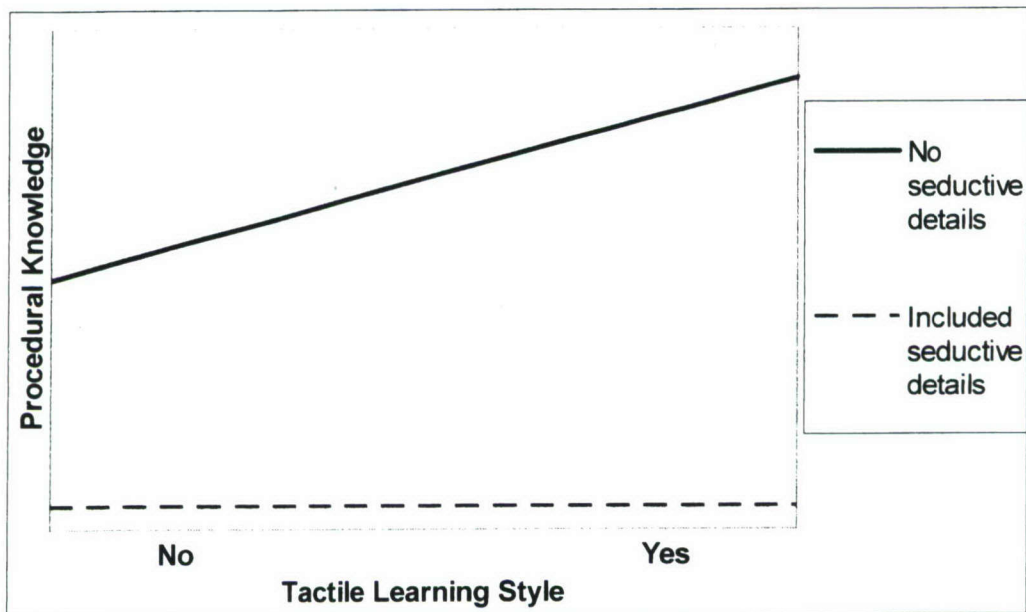


Figure 2. Interaction between seductive details and tactile learning style when predicting procedural knowledge test scores.



## **Research Approach – Study 2**

The second study was a replication and extension of the first study. We attempted to replicate the findings from Study 1 in a different setting using another training program (Microsoft Mailmerge). We extended the second study through testing the effects of different types of seductive details on recall and transfer performance. To better understand the seductive details effect, we tested whether they had a deleterious effect depending on whether they were independent or dependent on instructional content. For example, in the context of providing instruction on the use of Microsoft Mailmerge, an example of dependent seductive detail is “The Windows NT software was developed by Microsoft-Israel,” whereas an independent seductive detail is “Top graduate schools often accept up to only 10 applicants per year.” As can be seen in the examples, dependent seductive details are tangentially related to the instructional material, whereas independent seductive details have no relevance to the instructional material.

Seventy-seven participants were recruited for this study from a private Midwestern university. The independent variable consisted of three levels: no seductive details, independent seductive details, and dependent seductive details. As in Study 1, post-training measures were collected on a multiple-choice test of declarative knowledge and a performance-based measure of transfer after a time delay and distracter task.

## **Accomplishments – Study 2**

As in Study 1, there was no main effect for seductive detail (SD) condition on declarative knowledge test scores. There was, however, a main effect for seductive detail condition on transfer performance. Transfer performance was better in groups that were exposed to independent seductive details for the transfer task score ( $M = 15.62$ ,  $SD = 1.03$ ) compared to the control group ( $M = 11.15$ ,  $SD = 1.17$ ). There was no difference between the dependent seductive details ( $M = 13.03$ ,  $SD = 1.07$ ) and the other groups. Consistent with study 1 (and contrary to the findings of many previous studies), the introduction of (independent) seductive details had a facilitative effect on transfer performance.

## **Research Approach – Study 3**

Since we conducted two studies with results that were very different than those obtained by Mayer and colleagues (e.g., Harp & Mayer, 1997; 1998; Mayer et al., 2001), we attempted to conduct a tight replication of one of Mayer’s earlier studies. Because results of both prior studies conflict with those of previous research, we conducted a third investigation attempting to replicate as closely as possible conditions used in prior seductive details studies. Sixty-two undergraduates at a Southwestern university participated in the investigation for extra credit. Following the design in Harp and Mayer (1998), participants were assigned to one of four conditions: (1) a baseline condition, (2) baseline plus seductive details, (3) baseline plus seductive illustrations; and (4) baseline plus seductive illustrations and seductive text. In all conditions, participants read a scientific explanation of how lightening forms. Seductive details were in the form of interesting information about lightening but irrelevant to its formation (e.g., the number of Americans per year struck by lightening) and/or interesting pictures irrelevant to lightening formation (e.g., a high school football player whose uniform had been burned by



lighting). All text and seductive details were identical to those used by Harp and Mayer. Participants completed the training material and answered four open-ended questions applying what they had learned. Participant responses were scored by two researchers and summed across questions. Note that these transfer questions are actually problem-solving or applied questions rather than performance-based measures as used in Studies 1 and 2.

### **Accomplishments – Study 3**

Two one-way ANOVA revealed significant main effects for seductive details on both the number of main points recalled and scores across the four “transfer” or problem-solving questions. Post hoc comparisons of recall measures indicate that participants recalled the most main points in the base (no seductive detail) condition, and the fewest main points in the base + text + illustration condition. Post hoc comparisons revealed that problem-solving scores were lowest in the base + text + illustration condition, but there were no differences between the other three conditions. In general, these results are similar to those obtained by Harp and Mayer (1998), although not as strong for the seductive detail text and seductive detail illustration conditions. Interestingly, Harp and Mayer concluded that “seductive details do their damage” by interfering with the organization of information at the point of learning. However, visual inspection of the free recall measures in the three seductive details conditions shows strong organization of information. Even though upon presentation the seductive details were interspersed with the primary information, at recall, participants frequently presented the seductive details (organized) together at either the beginning or end of their recall statements.

### **Research Approach – Study 4**

In a phone conversation with Richard Mayer, Dr. Mayer speculated that one difference between some of our studies and his was that our studies provided less cognitive load on participants, and thus seductive details were less disruptive. For example, when learning new software, there may be a natural organization to the information, or learners can rely on prior knowledge of other software to organize the new information. Seductive details could be less disruptive under these conditions than if all information was new. Seductive details in general would be predicted to have the greatest effect when greater cognitive load was greatest. Dr. Mayer also speculated that there could be differences in the nature of our seductive details (from his). Over time, he had found that visually graphic or violent details tended to be the most disruptive.

To examine the effects of different levels of cognitive load and different types of seductive details, we conducted a fourth study. Sixty research participants from a private southwest university were recruited for the study. They were assigned to one of four cells in a 2x2 design. Participants read about how a car engine works. Participants either read one page at a time or two pages at a time (with the latter condition requiring them to store more information at one time, thus imposing greater cognitive load). Participants either read and saw neutral seductive details, or graphic ones (e.g., a car from a violent automobile accident, or female models posing at a new car show). We used a multi-item declarative knowledge measure to assess learning, and participants also rated their satisfaction with the training materials.



## **Accomplishments – Study 4**

There was no effect for cognitive load (one v. two pages) or seductive detail type (neutral v. graphic) on the knowledge test scores. Participants reading two pages at a time rated the materials significantly more confusing than did participants reading one page at a time. In sum, there was little support for either manipulation on learning, although the requirement to read two pages at a time may have created more cognitive load for learners.

## **Research Approach – Study 5**

Seventy-one participants were recruited for this study from a private Midwestern university. The students ranged from freshman to undergraduate seniors. Twenty-seven participants were females and 44 were males. Nearly all participants stated they were not familiar with Microsoft Mailmerge. Each participant was randomly assigned to one of four groups: (1) cognitive load + no SDs, (2) the control-no cognitive load + no SDs, (3) cognitive load + SDs, and (4) no cognitive load+ SDs.

The training provided instruction to participants on Microsoft Mailmerge—a function of the popular software package, Microsoft Word. The training session was an audio-visual file that participants listened to with headphones and viewed on a 17-inch computer monitor. The file contained animated videos with screen shots of Mailmerge and Excel programs. The overall topic of the training was to use Mailmerge to organize and send personalized letters in mass mailings. The training covered managing database information, filtering and sorting information, and inserting conditional statements. Cognitive load was introduced through use of a clicker. In the cognitive load condition, participants were required to click a clicker each time they heard the word “document” during training.

Demographics were taken before the training. Motivation was measured through an 8-item survey with questions like “I am motivated to learn the skills emphasized in the training program.” A 7-item reaction measure included questions like “I found the training coherent.” A 13-question, multiple choice post-test was administered to measure declarative knowledge. Transfer of training was measured through a task that included filtering, sorting and merging of letters.

## **Accomplishments – Study 5**

An ANCOVA was conducted to test for an interaction between cognitive load and seductive details with relation to transfer task scores. There was a significant interaction between cognitive load and seductive details ( $p < .05$ ). An ANOVA was then conducted to further test for group differences in training outcomes. A post hoc test (Tukey HSD) revealed that participants who experienced cognitive load + SDs, scored significantly ( $p = .04$ ) lower on transfer than participants with no cognitive load + no SDs.

## **Contributions to Basic Science**

The results from Studies 1 and 2 suggest that seductive details can be effective for transfer. Prior research has focused primarily on the effects of seductive detail on recall, finding a negative effect. It is interesting to learn that seductive details can have a positive effect on task performance following a delay from training.

Results across all studies suggest that seductive details may have an effect on recall measures, but these effects do not occur when recognition (multiple-choice tests) are used. Researchers need to exercise care in choosing the appropriate dependent variable, and theories on seductive details should account for differential effects based on test type.

Visual inspection of participant responses in Study 3 suggests that if seductive details have negative effects on learning, they do not do so by preventing organization of new information. Evidence from Study 5 (but not Study 4) suggests that increasing cognitive load may make seductive details more disruptive to learning.

Cognitive load theory suggests that learners can absorb a limited amount of material into working memory and if they are overloaded with information then they fail to form knowledge schemas that can be transmitted to long-term memory (Sweller, 1994). Cognitive load may be influenced by learner characteristics (e.g., cognitive ability or learning style), depth and complexity of content, or instructional design characteristics. There may be crucial “tipping points” for cognitive load to occur and thus for seductive details to do their damage. This point may also be dependent on individual differences, which we did not investigate in our research.

## **Potential Army/Military Applications**

The knowledge acquired from this basic research emphasizes the importance of monitoring and controlling levels of cognitive load in computer-based training studies. Cognitive load thus emerges as a key variable for understanding relations among learner capabilities, instructional design features, and learning during training. Seductive details are but one mechanism for increasing cognitive overload. A logical next step is to study more broadly multiple instructional strategies that enhance learning and transfer by decreasing the learner’s cognitive load. This research can be followed up by testing various design principles rooted in cognitive psychology in terms of their impact on cognitive load in various forms of computer-based training of work-related skills.

Understanding variables that affect learners’ ability to separate understanding of seductive details from their understanding of core content may have other applications for the military as well. For example, in game-based training, seductive details take the form of graphics and special effects that enhance the appeal of the game but might be unrelated to the purpose of training. Seductive details and cognitive load theory may provide a platform for studying boundaries of game fidelity. Alternatively, identifying learner factors related to the capacity to “separate wheat from chaff” might have implications for the designing effective training of intelligence analysts.



## References

- Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology*, 89, 92-103.
- Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, 90, 414-434.
- Mayer, R. E., Heiser, J. & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, 93, 187-198.
- Sweller, J. (1994). Cognitive load theory, learning difficulty and instructional design. *Learning and Instruction*, 4, 295-312.

## **Training for Efficient, Durable, and Flexible Performance in the Military**

**Contract #:** DASW01-03-K-0002  
**Institution:** University of Colorado

**Contract Dates:** 10/01/2002 to 9/30/2007  
**PI:** Alice F. Healy  
**Co-PI:** Lyle E. Bourne, Jr.  
**Liasons:** Stephen Goldberg, SSRU  
Robert Pleban, IFRU

**Problem(s)/Research Question(s)** – This project aims to test and develop principles of training that promote efficient learning, durable memory, and flexible transfer performance.

**Technical Barrier(s)** – Learning, memory, and transfer performance are not always highly positively correlated; for example, rapid learning often leads to weak long-term retention. There is, thus, a technical barrier for finding conditions that simultaneously optimize all three aspects of training.

**Significance/Impact for Basic Research** – The experiments conducted as a part of this project should produce data that will support the development of a general theory of training encompassing learning efficiency, memory durability, and transfer flexibility.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in the following ARI applied programs (among others):

- Virtual Intelligent Training for Objective Force Warriors (WP 294);
- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade (WP 211);
- Future Force Warrior Training (WP 215);
- VICTOR: Virtual Individual and Collective Training for Objective Force Warrior (WP 233);
- Training for Interactive Distributed Environments (WP 214); and
- Simulation-focused Collective Aircrew Training (WP 231).

### **Overview**

We have developed a set of training principles that optimize the efficiency and durability of trained performance. In addition, we have discovered that conditions that lead to durability often, and perhaps always, lead to limited flexibility or adaptivity. In fact, we have found that training has little or no benefit if there are discernable differences between the training and testing situations in the background or context, even if there are no changes made in the primary task requirements. The focus of the current project is, thus, to develop training procedures for knowledge and skill that will survive primary task or background changes and, thereby, produce flexible, as well as efficient and durable, performance in military tasks.



## Research Approach

The experiments in this project are divided into three major groups. Experiments in the first group are designed to understand how individuals can be trained to contend with an unpredictable flow of information often large in quantity, rapidly presented, and ambiguous. Experiments in the second group are aimed to identify training factors that promote adaptive and flexible performance in the field. The final group of experiments examines performance in dynamic and changing task environments. We conclude with an effort to create, still in the laboratory, a complex set of tasks similar to those encountered by a digitally proficient pilot operating a fully computerized cockpit, and not unlike those of the digitally proficient “land warrior” Soldier of tomorrow. The major aim of this set of experiments is to determine the extent to which training principles, first established in simpler laboratory tasks, generalize to performance under these more complex conditions.

## Accomplishments

In this summary, we focus on accomplishments in two experiments. Both of these experiments relate to understanding how individuals can be trained to contend with an unpredictable flow of information often large in quantity, rapidly presented, and ambiguous. The first experiment is also relevant to the identification of training factors that promote adaptive and flexible performance in the field. These two experiments have helped us to test and to increase the sphere of previously proposed training principles.

The first experiment used a message comprehension paradigm in which we examined subjects’ ability to remember and follow navigation instructions. We used this task to investigate variations in training to determine ways to optimize the understanding of, memory for, and execution of navigation instructions. In particular, this study tested three different training principles that had been proposed in earlier research using different tasks: (a) *difficulty of training* (any condition that causes difficulty during learning may facilitate later retention and transfer), (b) *specificity of training* (retention and transfer are depressed when conditions of learning differ from those during subsequent testing), and (c) *variability of practice* (variable practice conditions typically yield larger transfer effects compared with constant practice conditions).

To test the relative strength of these principles, subjects were trained in one of three conditions. During training trials in the *easy* condition subjects were given only short messages including from one to three commands, in the *difficult* condition they were given only long messages including from four to six commands, and in the *mixed* condition they were given messages of all six lengths. Testing occurred following a short delay filled with an irrelevant experiment. At testing, all subjects received messages of all six lengths. On the basis of the difficulty of training principle, subjects should do better at testing overall with hard training than with easy training. On the basis of the specificity of training principle, subjects should do better at testing on short message lengths with easy training than with hard training but should do better at test on long message lengths with hard training than with easy training. That is, there should be an interaction between training condition and message length. On the basis of the variability

of practice principle, subjects should do better at test with mixed training than with either easy or hard training.

We found a significant interaction of condition and message length, as depicted in Figure 1. The mixed group was best on all lengths but length 2, and the easy group was better than the hard group on the easy lengths (1-3, which they trained on), whereas the hard group was better than the easy group on the hard lengths (4-6, which they trained on). The results support the advantages of both specificity and variability of training but do not support the hypothesis that difficult training would lead to overall best performance at test. Thus, in terms of our principles, we found support for the principles of specificity of training and variability of practice but no support for the principle of difficulty of training.

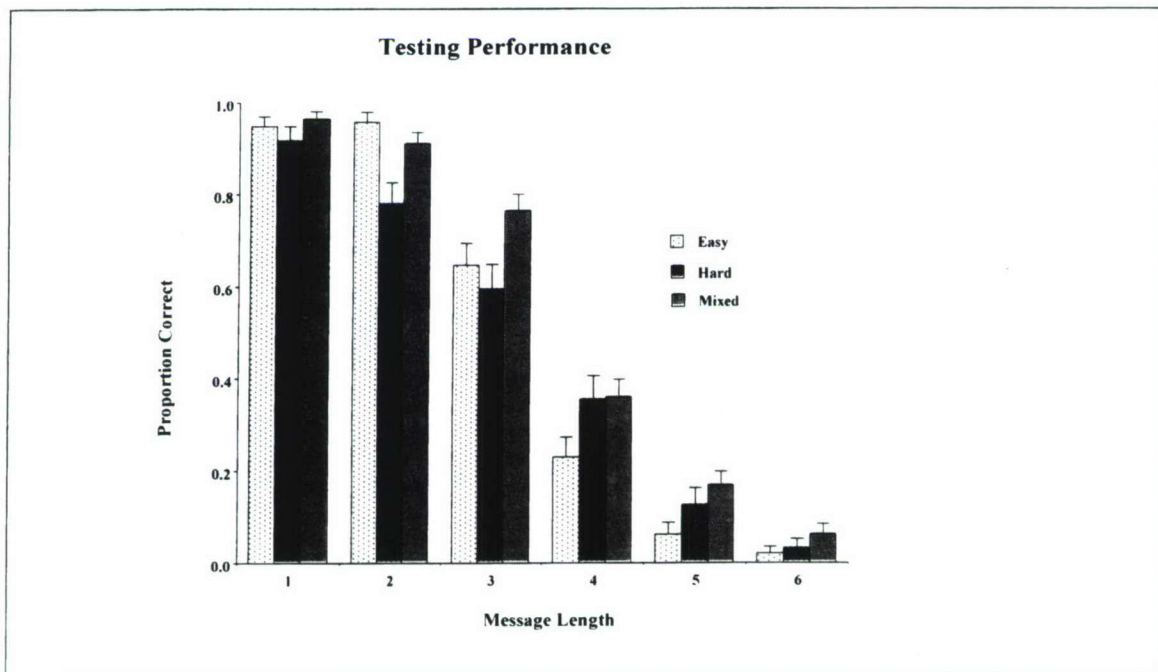


Figure 1. Testing performance across conditions.

The second experiment continues a line of investigation that we have been pursuing in which we are attempting to understand the processes underlying the bow-shaped serial position function evident in studies of memory for order information. Earlier experiments in this series examined memory for information either learned outside the laboratory or learned in a single list presentation in the laboratory. In this experiment, we used a novel training procedure in which list items were presented multiple times. This procedure enabled us to compare the relative contributions of two variables postulated to affect the serial position functions: familiarity of the items and distinctiveness of the positions. Another novel aspect of the present study was that it tested memory for spatial order, rather than memory for temporal sequence. Thus, unlike earlier studies, position distinctiveness was not confounded with temporal distinctiveness.

Many military tasks require the participants to learn a spatial ordering that changes dynamically in time. For example, command personnel must learn where own troops, enemy



troops, and various combat resources are located on the battlefield. Furthermore, our manipulation of item familiarity was much stronger than the manipulations used in previous studies of the serial position function.

We employed the technique we had developed earlier to investigate the strategic use of knowledge principle (learning and memory are facilitated whenever pre-existing knowledge can be employed as a mediator in the process of acquisition), in which subjects listed 10 of their friends and relatives, and these names of familiar individuals were included as stimuli in the experiment along with 10 names of unfamiliar individuals. There were two familiarity order groups that differed in terms of the assignment of names to list positions. In the familiar first group, familiar names were assigned to the first two list positions, unfamiliar names were assigned to the next two list positions, and so on throughout the list of 20 names. The opposite assignment of names to list positions was used for the unfamiliar first group. Following other procedures we developed earlier, subjects reconstructed the order of only a 12-name subset of the full list of 20 names. There were three serial position conditions that differed in terms of the 12-name subset of positions used for order reconstruction: 1-12, 5-16, and 9-20.

As shown in Figures 2 and 3, there were striking effects of both familiarity order group and serial position condition on the shape of the serial position function, indicating that familiarity of the items and distinctiveness of the absolute list positions both contribute to the serial position function in reconstructing spatial order information. The effects of item familiarity were particularly striking, thereby also extending the strategic use of knowledge principle to tasks involving reconstruction of order. This study demonstrates clearly that prior knowledge can be used effectively to learn new position information, and that finding should be relevant to training battlefield commanders who are required to learn location information, as described above.

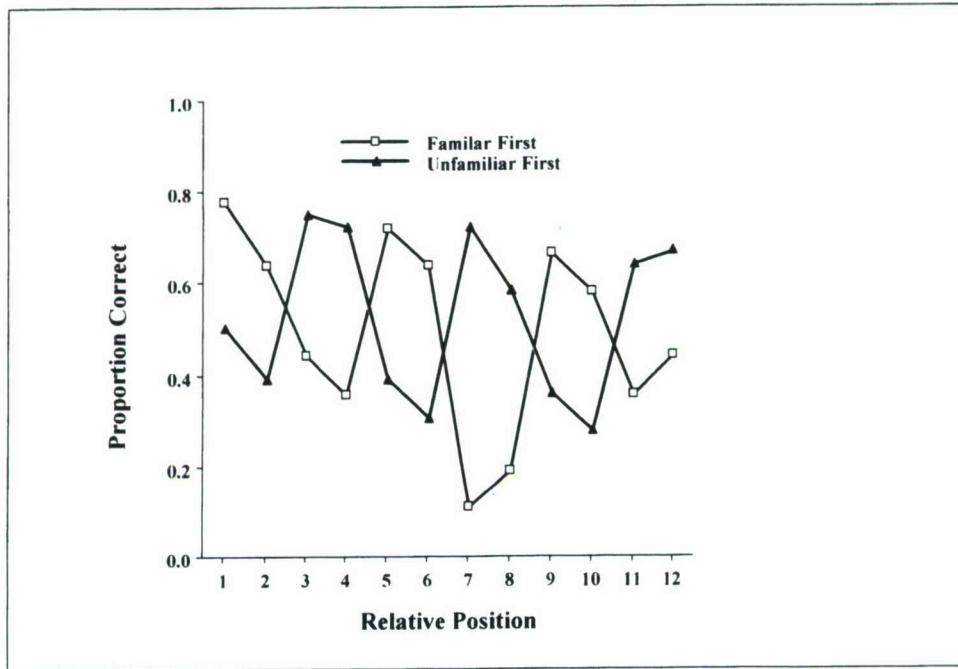


Figure 2. Effects of serial position.

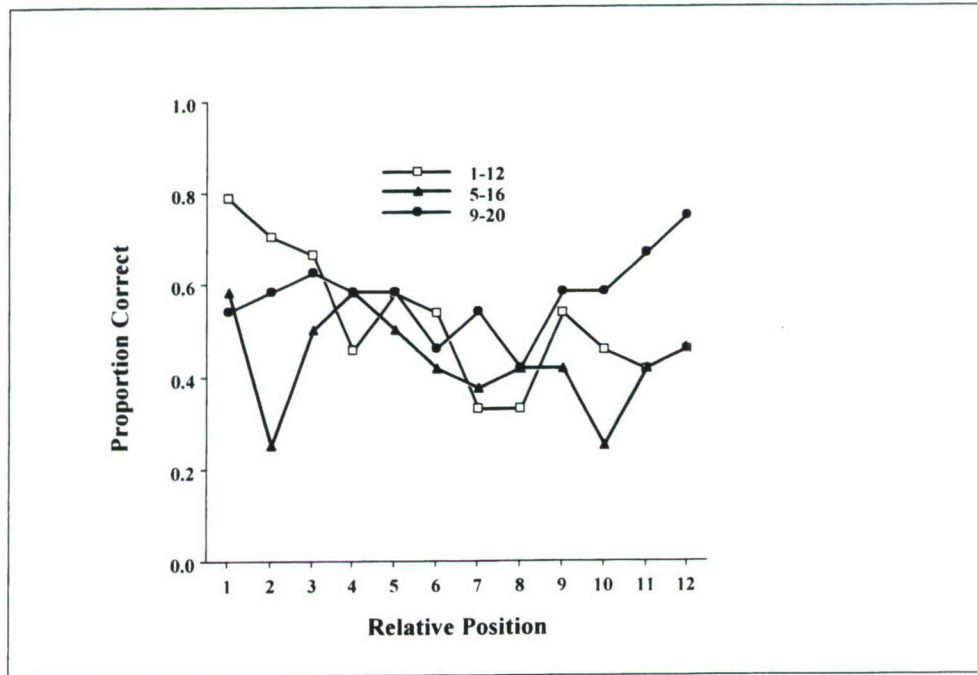


Figure 3. Effects of serial position.

### Contributions to Basic Science

We have proposed theoretical principles for optimizing training. The primary purpose of our experiments is to collect data that allow us to accept or reject each of these training



principles that we formulated on the basis of our basic laboratory research and to develop and test new principles that are supported by these data. For example, our recent study of comprehension of navigation instructions allowed us to confirm the specificity of training and variability of practice principles, and our recent study of serial order reconstruction allowed us to extend the strategic use of knowledge principle to a new domain.

### **Potential Army/Military Applications**

Our experiments should be used to drive applied research. To illustrate this potential symbiosis between basic and applied research, we give two brief examples. First, our research has demonstrated a high degree of specificity from training to subsequent application. In fact, we have shown that training is specific even to the length of messages that need to be understood and executed. Test performance was best following training with all possible message lengths. These findings have crucial implications for military training because instructors may assume that teaching a particular task through a limited number of examples will generalize fully to an entire domain even when the examples differ in a fundamental respect (e.g., length) from the test situations. However, our findings imply that to be effective, training should incorporate a full range of examples on critical task dimensions. In our research, we are testing the boundary conditions of this specificity of training and variability of practice principles using a variety of laboratory tasks, and we are exploring additional ways to overcome training specificity beyond increasing practice variability. Although the tasks used in our research are often components of military tasks and require digital proficiency, they are not the real military tasks currently being trained in the Army. We hope that applied research units are interested in testing whether the training principles we have developed would apply to such real tasks and whether the methods we hope to develop for overcoming the problem of training specificity could be adapted to improve military training. To that end, we visited and have had discussions with Stephen Goldberg (Chief, Simulator Systems Research Unit) about future collaborative research on the applicability of our training principles to simulator training. Second, we have shown that prior knowledge can be used to enhance the learning of spatial position information. We are presently conducting research to explore the boundaries of effective prior knowledge utilization. But the use of prior knowledge needs to be examined in the context of real military tasks as well, and we hope that applied research units will be willing and able to take on this examination.

### **Future Plans**

The original contract had a termination date of September 30, 2006. We requested and were granted a 1-year no-cost extension. During the remaining months of the extension, we will be completing the analysis and write-up of the experiments we have conducted, and we will be submitting manuscripts, where appropriate, to professional journals in which we will summarize our findings.



## **Understanding Aspects of Individual and Collaborative Skill Acquisition in Face-to-Face and Distance Training Situations**

**Contract #:** DASW01-01-K0003  
**Institution:** New Mexico State University

**Contract Dates:** 09/01/2001 to 12/2005  
**PI:** Adrienne Y. Lee  
**Co-PIs:** Douglas Gillan & Nancy Cooke

**Problem(s)/Research Question(s)** – How do teams learn at a distance? How does changing the context between training and test affect performance? What kind of training can we provide to improve that transfer between contexts?

**Technical Barrier(s)** – Cognitive issues for teams/group training is a relatively recent topic of study. Teams of more than two individuals are difficult to acquire and sustain for multi-day experiments. Improved technology allows for both more sophisticated studies and better measurement tools; however, this also means relying on outside vendors (to supply the advance software and programming support) and also on-site technical support.

**Significance/Impact for Basic Research** – Through this research, we will have a better understanding of the factors that affect team learning across contexts (i.e., the effect of interacting face-to-face versus communicating via technology, and what effect the context of complex software has on this interaction).

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- Training for Interactive Distributed Environments; and
- Other training programs such as Managing Training and Providing Feedback within Networked Embedded Training.

### **Overview**

The purpose of this research is to examine: a) whether teams training together in the same location (co-located) will train more quickly and efficiently than teams who are not in the same location (distributed); b) whether testing in the same situation/context (co-located to co-located and distributed to distributed) is better than training in different situations/contexts (co-located to distributed and distributed to co-located); c) whether we can develop training to improve the transfer between contexts; and d) whether the training will improve learning.

### **Research Approach**

This investigation asked teams of three individuals to learn a complex task and then use that knowledge to work together to solve some new tasks. Originally, for the tasks, individuals were asked to learn how to operate an Unmanned Air Vehicle (UAV) where the three individuals, each with different jobs, must fly a UAV to various locations and take pictures of specific targets. After an initial investigation, the new focus shifted to peacekeeping missions where three individuals manage different resources in Support and Stability Operations (SASO). Both of these contexts are simulated in the laboratory and training/testing is performed using the following methodology.

First, individuals learn the complex task either together (face-to-face, co-located) or apart (distance, distributed). Then a new, equally complex task is chosen and the individuals are asked to perform the new task. They are either asked to stay in the same context or change to the other context. Initially, for the UAV task, co-located context, the computer consoles were in a semi-circle that allowed individuals to speak over-the-shoulder to each other; for the distance context, the individuals were separated by a screen, with one in another room. For the SASO task, co-located, individuals are facing computes in a circular configuration which allows them to talk to each other easily; for the distance context, the individuals are in completely separate rooms with sound material on the walls. The new technology allows for smaller, lighter computer equipment that can be easily moved to different rooms and communication occurs through light headsets.

## Accomplishments

In the spring and fall 2002, the first investigation on co-located/distance team training and transfer was performed in the UAV CERTT lab. Performance results are shown below. Although all teams received the same initial (declarative) knowledge training, distance teams outperformed co-located teams throughout the initial hands-on training sessions and after transfer. The distance teams reached a plateau but this was probably due to a lack of feedback. After transfer, all teams experienced a decrement in performance (similar to Singley & Anderson, 1989) but the distance teams (i.e., those who trained at a distance and either stayed in the same distance condition or transferred to a co-located condition) showed a greater improvement for the two training missions after transfer. These results may have been due to the small numbers of teams or the experimental setup in the UAV lab which may have suppressed co-located performance.

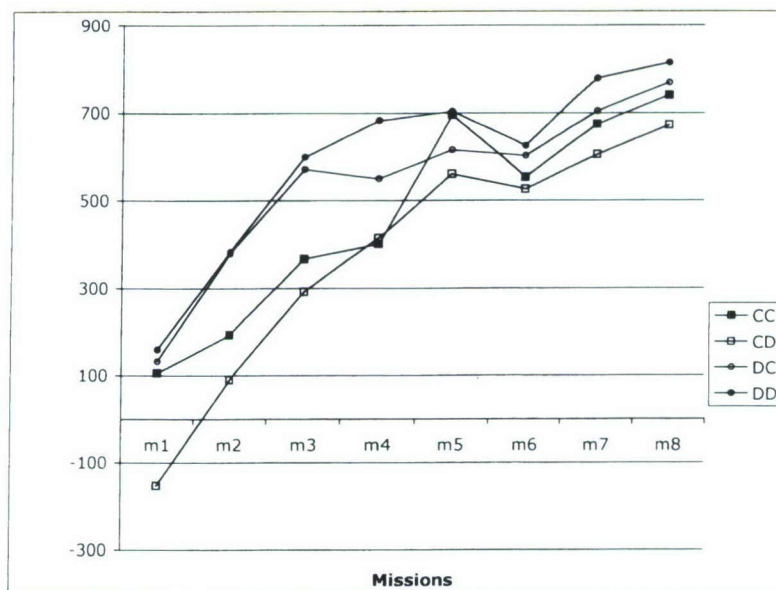


Figure 1. Performance across teams from Experiment 1.

Note. A change in context occurs at Mission 7. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.



In 2003 we developed the SASO lab and tested the software both among the graduate student assistants and with practice teams. We were able to get necessary changes to the SASO software and to debug that software, install video and audio recording, re-configure a lab space to house the hardware, and train assistants on the task. From spring 2004 through spring 2005, we replicated the investigation in the SASO lab. The main differences in physical context were described above; however, we added a communication training component. Thus, we can see whether the change in the technology has a bigger effect than a change in the physical context.

We ran 60 teams to test both the conditions set forth for Experiment 1 and push-to-talk versus no push-to-talk. Results for Experiment 2 are shown in Figures 2 through 4. The pattern of results for push-to-talk is different than for no push-to-talk. If you look at the training results, push-to-talk adds quite a bit of load. The push-to-talk data by condition over missions is unreliable with performance all over. However, the no push-to-talk data show more regularity. They demonstrate that staying in the same context is better than changing context.

The data also included transcripts of conversations among team members. Subjective analysis indicates that including a communication component both in the beginning of the training and before the first mission was effective. However, additional (possibly automatic) analysis of the transcripts of conversation may be useful (and is being performed). In addition, the results have been examined for cross-cultural individual difference factors and team trust issues.

We are currently replicating the investigation again in the SASO lab using a change in context in the actual SASO software as described below.

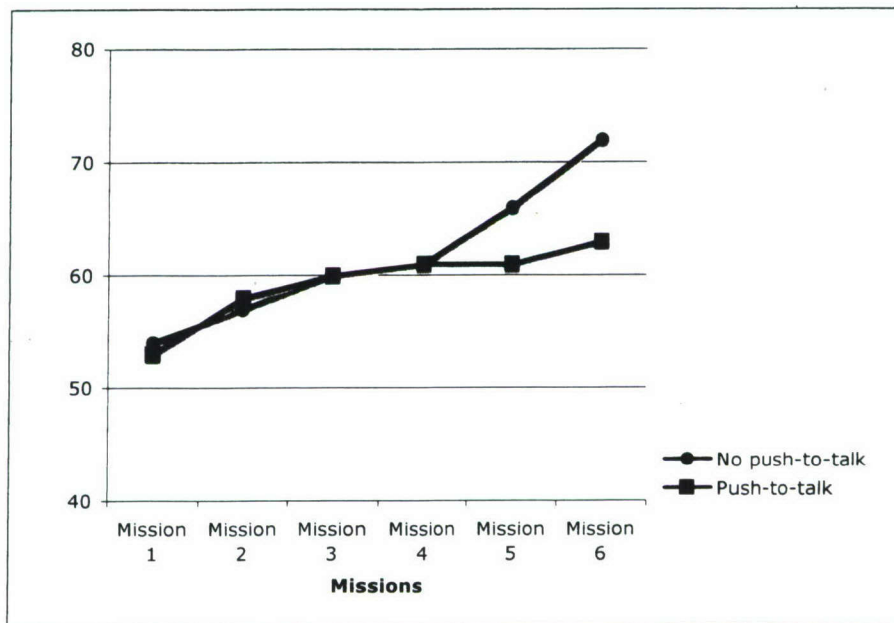


Figure 2. Experiment 2 results for push-to-talk versus no push-to-talk.



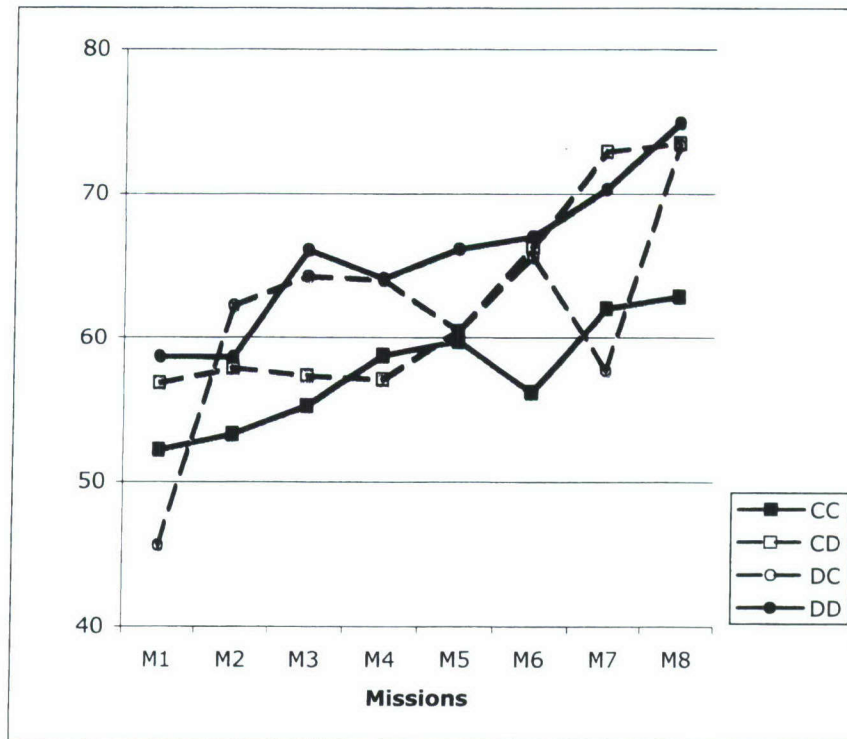


Figure 3. Experiment 2 results for push-to-talk results by condition.

Note. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.

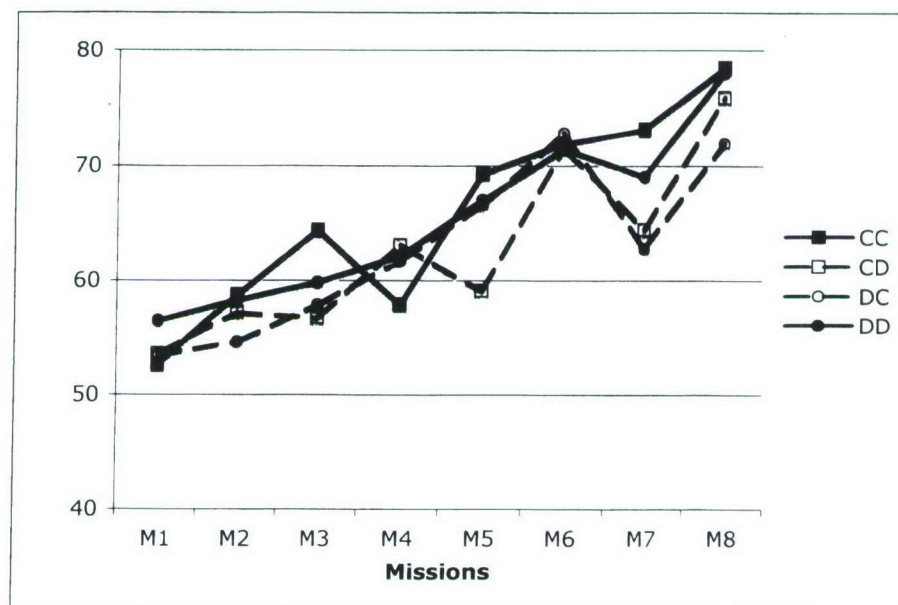


Figure 4. Experiment 2 results for no push-to-talk results by condition.

Note. CC= co-located; CD = co-located to distributed; DC = distributed to co-located; DD= distributed.

## **Contributions to Basic Research**

In recent years, the advancement of military technology has resulted in highly complex skills that need to be acquired and maintained to use that technology (Barry & Runyan, 1995). Consequently, the demand for ongoing innovations including distance training has increased. Distance training has been shown to be extremely cost effective and has produced similar learning outcomes. Although extensive research on distance learning exists, few studies have focused on group (collaborative) distance training delivered by internet/Web-based technologies.

A parallel development has occurred in the area of team training. Even though group (collaborative) learning has been the focus of many studies (Slavin, 1996) and progress has been made on knowledge measurement at the individual level, the measurement of team knowledge, and team cognition in general, is still in its infancy (Cooke, Salas, Cannon-Bowers & Stout, 2000). Thus, research on how to improve team distance learning can contribute significantly to the field in several areas including distance education and across-context team transfer.

Interest in distance education has increased due to a concerted effort on the part of public educational institutions to reach new populations of students who might not otherwise be able to attend. With advancements in technology, this has been possible (particularly in the use of Web-based training). On the other hand, few controlled studies exist to determine what is truly beneficial.

Controlled studies for team distance training could also contribute to the transfer literature generally. Research has been performed on individual transfer (Singley & Anderson). Although specifications for transfer are delineated, research on context effects has not been as conclusive (see McDaniel, Anderson, Einstein & O'Halloran, 1989 or Wickens, 1987). The current research project is focused upon describing the effects of a particular physical context change on team performance (with a focus on cognitive skills, but also some measurement of social skills).

## **Potential Army/Military Applications**

The applications to the military were expected to be in principles for distance training and transfer (changing from one situation to another) situations. These studies were designed to determine what conditions promote distance training and transfer and what training is needed to improve team and distance transfer. In addition, within the studies, various assessment measures were used that will focus on individual and team cognitive and social (social-cultural) skill development.

## **Final Summary**

These experiments provided many hours of training compared to studies usually performed in university laboratories. Here are our findings and implications.

Experiment 1 indicated the importance of communication training. Teams that may be composed of people who do not know each other (from different parts of the country) may need



to become comfortable in communicating with each other before a team task can be performed. Unfortunately, people are often expected to learn how to communicate through learn-by-doing or by exposure.

In Experiment 1, the hardware was imposing and took time to train. In addition, only push-to-talk was used. In Experiment 2, we directly examined push-to-talk versus no push-to-talk. The hardware was less imposing (more familiar and easier to learn). The results, after separating push-to-talk from no push-to-talk, resembled what one would expect – a change of physical context and software context would result in more difficulties than staying in the same context. Although push-to-talk is a normal function of technology in the military, it is not usual outside of the military. Further, when people are face-to-face, having to press a button to speak is somewhat unnatural. A more general conclusion is that individuals (and teams) need training on just the hardware aspects before trying to train on the target knowledge available in the simulations. One needs to examine the aspects of the hardware (and software) to locate potential difficulties before focusing on whether the goals of learning can be achieved.

The results in both experiments were different; however, the hardware and software were also different. Note that Experiment 1 had far fewer teams. Even though numerous other differences between these experiments may have impacted the results, these studies together indicate how many different types of context might exist for the individual or team. There's the physical context (same room/different room/different floors), the hardware context (large imposing/unfamiliar or familiar) and the software context (SASO's country map & stories, UAV maps & buildings). If the context (simulation or hardware) is particularly compelling, then the physical context (room, building, chairs, etc.) may not play as large a role. However, identifying what the critical context is for the team or individual may be the harder task.

Team performance can resemble individual performance. For interference, a decrement would be expected at transfer to a different context, but after a little more training, the performance will jump back to the original performance before transfer. For most teams, this result was found. Thus, in most cases, a team that performed peacekeeping in one country could be brought together in another country with a temporary loss of performance. We do not know how much of a decrement would occur or how long it would take to bounce back, but at least we do know that the training is not lost permanently.

## **The Integration of Implicit and Explicit Knowledge in Skill Learning**

**Contract #:** W74V8H-04-K-0002

**Institution:** Rensselaer Polytechnic Institute

**Contract Dates:** 09/2005 to 10/2008

**PI:** Ron Sun

**Co-PI:** Robert Mathews

**Liaison:** Dan Horn, BRU

**Problem(s)/Research Question(s)** – How is implicit knowledge acquired from experience integrated with explicit knowledge from analytical thinking, and what role does this integration play in skill learning and in leading to skilled performance?

**Technical Barrier(s)** – The interaction of these two types of knowledge is still poorly understood and more importantly, the integration of these two types of knowledge is heretofore unexplored. The process of interaction and integration appears to be highly complex, varied, and multi-faceted.

**Significance/Impact for Basic Research** – The major contribution of this work lies in coming up with a significant new theory that explains a range of human data (skill learning phenomena) on the basis of the integration of implicit and explicit knowledge. The integration of these two types of knowledge is heretofore unexplored in the literature. Therefore this project will lead to advancing the psychology of skill learning and better understanding of this essential aspect of human cognition.

**Potential transitions** – Knowledge gained in this basic research may be usefully employed in:

- Future Force Warrior Training program (WP 215) - Training programs that facilitate rapid accurate decision-making; and
- Various other training programs, including VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233); SIMAIR: Simulation-Focused Collective Aircrew Training (WP 231); and Training for Interactive Distributed Environments (WP 214) - How implicit and explicit training interact and affect skill learning should be relevant to all of these programs.

### **Overview**

It has been shown that high levels of skills depend on both conceptual (explicit) and subconceptual (implicit) knowledge. In our prior work, we have demonstrated that there is often a lack of awareness of experiential knowledge and, in fact, implicit experiential knowledge may sometimes be incompatible with explicit conceptual knowledge. These problems create serious challenges for training and learning in the military as well as the civilian contexts. The purpose of this research program is to better understand the integration of these two types of knowledge in the course of skill learning and how their integration may lead to better skill learning and better skilled performance. Specifically, we will (1) investigate the integration of implicit knowledge (from experiential learning) and explicitly formulated conceptual knowledge in the development of skills and expertise, (2) explore when and how conscious reflection and resulting conceptual knowledge may be integrated with implicit knowledge to enhance, rather than to interfere with, experiential learning, (3) develop computational models and theories of human



skill learning that capture the fine-grained details of the integration of these two types of learning, which may be of use in understanding and improving training, on the basis of our experimental results.

## **Research Approach**

This project investigates the integration of implicit and explicit knowledge in skill learning through experimental, theoretical, and computational means. In part, this work develops further a computational cognitive architecture CLARION, especially in terms of capturing of process details of bottom-up learning and top-down learning. These two processes represent two hypothesized ways of integrating implicit and explicit knowledge. Equally important in this project are a set of human experiments to explore different methods of facilitating the integration in order to enhance skill acquisition.

The human experiments will use a more complex process control task than those typically used in the implicit learning literature that we refer to as a diagnostic task. The task involves several interrelated input and output variables. The task captures real world situations in which an operator (e.g., a manager) is attempting to control a main target variable (e.g., field performance) but must also monitor several other variables to be sure they remain in acceptable levels (e.g., desire to re-enlist, or morale). It also corresponds to situations where sequences of decisions must be made (selecting one or more input variables to use on each case) before feedback begins arriving about earlier decisions. This is analogous to a manager trying different treatments to improve workers' performance and waiting to see results, then making the decision to continue current treatment or to try something new. It also permits study of the effects on learning of individual variability in treatment outcomes (e.g., not all workers respond alike to the same treatment). While the task is dynamic, it provides feedback by discrete time steps (i.e., after each round of decisions, feedback is provided on the effect of the treatment decisions on each individual case). This division of performance into discrete time steps provides the opportunity to reveal learning strategies and to view changes in the learning processes over time.

In addition, the task contains a special model-building screen to develop and/or to reveal participants' explicit hypotheses about the relationships among the variables. Participants are told that their goal is to figure out the relationships among input and output variables and correctly map these relationships on the model-building screen. Responses on this screen reveal participants' conscious (explicit) knowledge about strength and direction of relations among input and output variables and indicate their confidence in their responses. Participants also will indicate what they plan to investigate in the next sequence of task performance.

In various experiments, opportunities to switch from the diagnostic task screen (assigning treatments to individuals and obtaining feedback from the past decisions on all output variables) to the model building screen will be controlled. In some experiments, participants will perform the task at a fast pace (they must respond every six seconds) to build implicit knowledge of the task while limiting time available to develop conscious hypotheses to test. Then, in a second phase of the experiment, they will be allowed access to both screens to study how they translate their implicit knowledge of the task into an explicit model of the task. In other experiments, participants will be encouraged to engage explicit learning processes to learn how to perform the



task. They will be required to formulate and test their hypotheses by switching back and forth from the model screen to the task screen. These experiments will provide us with snapshots of how people attempt to implicitly and explicitly learn the task. Subsequent experiments will test various types of integrated training such as providing initial (partially reliable) explicit knowledge about the relations among variables. Other variables to be studied will include the presence or absence of hints or cognitive aids (e.g., a history screen that allows learners access to previous inputs and their effects on a given individual), and type of task goal - whether the task goal is performance based (e.g., getting all scores into the target zones) versus discovery oriented (e.g., testing the effects of all treatment combinations).

## **Accomplishments**

This contract began in September of 2005, starting with a major development of software for experiments. We are now completing the first series of experiments using the new software.

We have already made an interesting discovery. When a treatment has a strong positive effect on the main target output variable but also has a negative “side effect” on one of the other output variables, participants are generally unaware of the side effect but discount (reduce) the estimated positive effect of the treatment on the main target output variable. This discounting effect is in proportion to the size of the negative side effect and does not go away even when participants are instructed to pay special attention to the output variable that has the side effect. This effect appears to be unconscious (implicit) but influences conscious estimates of effect size on the main target output variable. We are now conducting additional experiments to see if this effect increases or diminishes when training emphasizes explicit (responding to the model screen) or implicit (just trying to control the variables) learning.

During this time, we also wrote and published an article involving two artificial grammar experiments that demonstrates the importance of including both bottom-up and top-down learning mechanisms to adequately account for artificial grammar learning. Across two experiments, we trained participants using a string edit task and highlighted relatively low-level (letters), medium-level (chunks), or high-level (structural, i.e., grammar diagram) information to increase the efficiency of grammar acquisition. In both experiments, participants who had structural information available during training generated more highly accurate strings during a cued generation test than other conditions, with equivalent speed. Experiment 2 revealed that structural information only enhanced acquisition when relevant features were highlighted during the task using animation. We suggest that two critical components for producing enhanced performance from provided model-based (explicit) knowledge involve: (1) using the model (explicit knowledge) to acquire experience-based (more implicit) knowledge rather than using a representation of the model to generate responses and (2) receiving that explicit knowledge precisely when it is needed during training. Our results were most supportive of the notion that a combination of top-down (model-based, explicitly driven) and bottom-up (experience-based, implicitly driven) processing might be a particularly powerful way to increase the acquisition of expertise (e.g., Sun, 2002; Sun et al., 2005). However, our work also suggests integrating these types of knowledge is not easy. It is clear that simply providing information about the underlying structure of the grammar and exposing participants to exemplars during training is not sufficient.



Simulations of various combinations of explicit and implicit learning have also been conducted, and we are in the process of analyzing the results and developing new theoretical frameworks.

### **Contributions to Basic Research**

The major contribution of this work lies in coming up with a significant new theory that explains a range of human data (skill learning phenomena) on the basis of the integration of implicit and explicit knowledge. One product of this effort is a conceptual framework, which addresses the ways with which these two types of knowledge may be integrated to produce expertise. This theory (the CLARION model) suggests that performance can be controlled by either a subconceptual knowledge base (implicit mode) or a symbolic conceptual mental model (explicit mode). Implicit control is fast but prone to error, particularly in early stages of skill acquisition. Explicit control is more accurate but slow to apply, and prone to loss by forgetting over a retention interval. Their integration may lead to better learning and better performance.

A computational cognitive architecture, CLARION, which is substantially different from other existing cognitive architectures, will be further developed in this work to simulate and capture a wide range of quantitative data that are related to the integration of the two types of knowledge, based on the above ideas. This will help us to explain (and eventually to predict) training and learning processes. We will carry out simulations to generate new insights and interpretations that can further explicate the integration of implicit and explicit processes. These outcomes (data, models, and theories) will likely provide a new perspective on skill learning. Our models and theories will be useful in better understanding human skill learning theoretically as well as in helping to improve training processes in practice.

### **Potential Army/Military Applications**

This research links to applied programs on training and learning. Specifically, our basic research centers on understanding learning and cognition in terms of the integration of implicit and explicit processes, and thus it involves testing and developing learning and training principles that may be used to enhance human learning. The goals of the basic research align with those of the applied programs. Both focus on training effectiveness. Hence, work from our basic research could inform and be applicable to work in the applied programs. For example, our work may offer training principles that enhance training effectiveness, which can then be incorporated into an automated tutoring system. There are of course many other ways in which the results of our basic research program could be employed in the applied programs' systems, tools, and other products.

We expect that Army applications of this research will be in the area of training and human performance. A basic problem for the Army is how to ensure that novices in a Military Occupational Specialty (MOS) move quickly to more advanced performance (and perhaps to expertise) as a result of their training. In addition, most training focuses on teaching conceptual (explicit) knowledge rather than setting up the opportunity for substantial experiential (mostly implicit) knowledge. While this may be appropriate for some specialties, some other specialties involve working with complex systems that are better learned initially through extensive



experiences than with lectures or textbook lessons. As service personnel gain in expertise, it may often then become appropriate to focus more on conceptual (explicit) knowledge. In this process, the integration of the two kinds of knowledge is expected to be highly important. Our research will lead to some initial guidelines about how to best facilitate knowledge integration and thus learning and performance.

## **Future Plans**

Our contract began towards the end of Fiscal Year 2005. We have acquired new equipment and developed new software for conducting human experiments. Now on that basis, we have begun to conduct the first set of experiments as specified in our proposal.

The new human experiments use a more complex process control task than those typically used in the implicit learning literature. It has five input variables that can interact on five output variables. This task (the diagnostic task) has a direct analog to real world situations such as making managerial decisions or clinical practice in medicine. In these situations, learners must contend with multiple sources of variability (i.e., unreliable explicitly provided information, individual variability in treatments, and client turnover). This task will allow us to study effects of these natural sources of variability on implicit and explicit learning outcomes, and their integration. Our previous studies have found implicit learning to be more tolerant of learning under noisy conditions. We also plan to study the types of errors learners make under these conditions and how to prevent them.

In addition, the diagnostic task contains a special model-building screen to develop and reveal explicit hypotheses about the relationships among the variables over time. In various experiments, opportunities to switch from the task screen to the model building screen will be controlled. In some experiments, participants will perform the task at a fast pace (must respond every six seconds) to build implicit (without explicit) knowledge of the task. Then, in a second phase of the experiment, they will be allowed access to both screens to study how they translate their implicit knowledge of the task into an explicit model of the task. In other experiments, participants will be encouraged to engage explicit learning processes to learn how to perform the task. They will be required to formulate and test their hypotheses by switching back and forth from the model screen to the task screen. These experiments will provide us with snapshots of how people attempt to implicitly and explicitly learn the task. Other experiments will test various ways of integrating implicit and explicit training. Other variables studied will include various hints to help build accurate models and whether task feedback is performance (error detection) focused versus discovery (creativity) focused.

Simultaneously, we will develop the basic outlines of computational models for capturing various methods for integrating implicit and explicit knowledge in skill learning, namely various bottom-up and top-down learning algorithms. We will then test them against human data to be generated from human experiments. We also will work on further cognitive architecture developments.

We will continue to prepare manuscripts of theoretical and/or experimental papers, arguing for and developing our unique approach.



**BRU RESEARCH OBJECTIVE #2: PROVIDE  
FUNDAMENTAL KNOWLEDGE TO IMPROVE LEADER  
AND TEAM PERFORMANCE**

Research under this objective provides concepts and methods for accelerating leader development, understanding and developing leader adaptability and flexibility, and discovering and testing the basic cognitive principles that underlie effective leader-team performance. Understanding the dynamics of small group leadership in face-to-face and distributed team environments is critical to this research objective as well.

## **Leadership: Enhancing Team Adaptability in Dynamic Settings**

**Contract #:** 1435-04-03-CT-71272  
**Institution:** University of Pennsylvania

**Contract Dates:** 01/01/2003 to 09/30/2006  
**PI:** Katherine J. Klein  
**Co-PIs:** Steve W. J. Kozlowski &  
Yan Xiao  
**Liaisons:** Stan Halpin, LDRU  
Scott Graham, IFRU

**Problem(s)/Research Question(s)** – What predicts *individuals'* adaptive performance in dynamic settings? What predicts *teams'* adaptive performance in dynamic settings? What can *team leaders* do to enhance adaptive individual and team performance?

**Technical Barrier(s)** – While research on leadership is abundant, as is research on teams, surprisingly few researchers have focused specifically on *team leadership*. Further, it is challenging to identify, gain access to, investigate, and/or stimulate truly *dynamic work settings*.

**Significance/Impact for Basic Research** – Our findings will help to clarify the nature and antecedents of adaptive individual and team performance in dynamic settings, expanding research on (1) leadership; (2) team effectiveness; and (3) dynamic work contexts.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- LEADERSHIP: Developing Leaders in a Changing Army (WP 103);
- Future Force Warrior Training (WP 215);
- Assessing and Developing Leaders Within Special Operations Units (WP 218);
- Accelerating Leader Development (WP 269);
- Accelerating Leader Development (WP 285);
- SELECT21: Selection, Classification, and Performance Metrics for the Future Force Soldier (WP 257) and ATO: IV.HS.2002.01; and
- FUTURE TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211).

### **Overview**

Our research was designed to illuminate the influence of individual differences, team characteristics, and leadership on individual and team performance in dynamic work environments. Dynamic settings are work environments in which:

1. Diverse specialists work in teams to perform highly interdependent tasks;
2. Tasks are high in novelty, uncertainty, and urgency;
3. The pace of work is varied and unpredictable as emergency events occur frequently but at unpredictable times;
4. Team composition (i.e., team membership) changes frequently, such that team members may not know many of the individuals on their team; and
5. Effective task performance is dependent on team member learning, development, and adaptation.



Theory and research regarding the factors that allow individuals and teams to thrive in such settings are extremely limited. Our research helps to fill this gap in the literature. Ultimately, our work will inform training specifications for leader development so that Army leaders are equipped with the skills needed to shape and influence team learning, development, and adaptability.

## **Research Approach**

We conducted five interrelated research projects, combining research methods and approaches—including comprehensive foundational literature reviews, theory development, experimental research in a laboratory setting, qualitative case study research, and longitudinal survey research in the field—to build new understanding of the ways in which leaders may enhance team learning, coordination, and adaptive performance in dynamic work environments.

More specifically, we collected qualitative data in a real-life, dynamic work setting: the Maryland Shock Trauma Center (STC). STC is the hub of Maryland's system of emergency trauma care, treating over 6,000 victims of traumatic injury each year. We complemented the real-world insights that we gained in the STC with rigorous, experimental research in the MSU ADAPT Lab (Accelerated Development and Addaptive Performance Training). Our experimental work was based on the theoretical foundation of self-regulation as a means to examine the psychological mechanisms underlying learning, motivation, and performance. We extended and enriched these efforts by conducting detailed reviews of the literature, engaging in theory-building, and studying the interactive effects of team composition and leader behavior in a longitudinal survey study of national service teams.

## **Accomplishments**

In our experimental research in the MSU ADAPT Lab on complex skill acquisition, we found that orienting team members toward learning (via goal content and goal frames) is a potent means to enhance the nature, focus, and quality of self-regulatory processes, learning, and performance outcomes. Principles from this research may guide the development of simulation tools and guidelines for team leaders. For more detailed information about this research, see:

Kozlowski, S. W. J., & Bell, B. S. (2006). Disentangling achievement orientation and goal setting: Effects on self-regulatory processes. *Journal of Applied Psychology*, 91, 900-916.

Our foundational review on team effectiveness documented several critical cognitive, motivational, and affective team processes that contribute to team effectiveness and pointed to leadership and team development as leverage points for enhancing team effectiveness. To read this review of the team effectiveness literature, see:

Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams (Monograph). *Psychological Science in the Public Interest*, 7, 77-124.

Our conceptual analysis of dynamic team leadership addressed gaps in the mainstream leadership literature. Our theory of dynamic team leadership specifies how team leaders can



shape, influence, and harness self-regulatory processes to guide team development and the emergence of key team processes needed for adaptation and effectiveness. The theory is presented in:

Kozlowski, S. W. J., Watola, D., Nowakowski, J. M., Kim, B., & Botero, I. (in press). Developing adaptive teams: A theory of dynamic team leadership. In E. Salas, G. F. Goodwin, & C. S. Burke (Eds.), *Team effectiveness in complex organizations: Cross-disciplinary perspectives and approaches* (SIOP Frontiers Series). Mahwah, NJ: LEA.

Our qualitative research conducted in an emergency trauma treatment center underscored the importance of dynamic team leadership. Senior team leaders in this setting engaged in “dynamic delegation,” repeatedly delegating the active leadership role to, and withdrawing the active leadership role from, more junior leaders of the team in response to rapidly changing task contingencies. Dynamic delegation allowed teams to perform reliably while also building their novice team members’ skills. This study appears in:

Klein, K. J., Ziegert, J. C., Knight, A. P., & Xiao, Y. (2006). Dynamic delegation: Shared, hierarchical, and deindividualized leadership in extreme action teams. *Administrative Science Quarterly*. 50, 590-621.

Finally, our longitudinal investigation of leadership, diversity, and team conflict, highlighted the need for leader responsiveness to their teams’ deep diversity. When team members’ values differ, leaders who structure their teams’ tasks (by assigning tasks, setting deadlines, specifying standards, etc.) may be particularly effective in preventing team conflict and facilitating rapid coordination and adaptation. For more information, see:

Klein, K. J., Knight, A. P., Ziegert, J. C., Lim, B. C., & Saltz, J. L. (2007.) *When team members’ values differ: The moderating effects of team leadership*. Working paper. University of Pennsylvania, The Wharton School.

### **Contributions to Basic Science**

Our research sheds new light on the psychological mechanisms underlying individual and team self-regulation in dynamic work settings. Further, our research identifies leader behaviors and functions (e.g., goal clarification, feedback, coaching) that enhance individual and team self-regulation and thereby enhance individual and team learning and development in dynamic settings. Current research on leadership and on individual and team performance is dominated by relatively static, structural approaches. Our research highlights the dynamic nature of individual, team, and leader performance required in dynamic work settings.

### **Potential Army/Military Applications**

Our research findings have implications for military leadership, training, selection, and team (e.g., platoon) design. The knowledge we are generating can be applied to improve leadership (in action), leader development (training specifications for leader capabilities), and training design and delivery (what we develop can be delivered by leaders in action or by technology-based training systems). Our findings can also inform the selection of Soldiers for



work in dynamic team settings, shedding light on individual differences that predict effective learning and performance in dynamic settings. Finally, analyses of the role that leaders may play in attenuating the potentially negative effects of team values diversity clarifies the leader behaviors likely to be most effective when Soldiers' values differ.

## **Final Summary**

Adaptive team performance is multi-determined. Adaptive individual and team performance reflects the *characteristics of individual team members*, most notably their learning goal orientation. Further, adaptive individual and team performance reflects the *behaviors of team leaders*. Team leaders may cultivate team members' learning orientation and skill acquisition by coaching and training their team members, by providing structure, and by enacting dynamic delegation. In highly effective teams, *team processes*—including team efficacy, transactive memory, and team cohesion—facilitate adaptive performance. Finally, skilled team leaders enhance their teams' adaptive performance by adjusting and matching their leadership behaviors to *critical contingencies*, including changes in team composition and shared expertise, values diversity, and shifts in the team's task engagement cycle.

## **Self-Initiated Development of Leadership Capabilities: Toward Establishing the Validity of Key Motivational Constructs and Assessment Tools**

**Contract #:** W74V8H-05-K-0001  
**Institution:** Georgia State University

**Contract Dates:** 11/01/2004 to 10/31/2007  
**PI:** Todd J. Maurer  
**Liaison:** Larry Laffitte, LDRU

**Problem(s)/Research Question(s)** – The problem addressed in this research is to identify and validate new individual difference characteristics that are relevant to motivating leadership development, as well as ways of measuring those differences in people.

**Technical Barrier(s)** – Little is known about predicting leadership development behavior because most research has been directed at predicting the performance of leaders.

**Significance/Impact for Basic Research** – New behavioral constructs are needed that will be useful in understanding, predicting and ultimately enhancing leadership development. It is expected that hypothesized relationships of these leadership development constructs/measures with each other and with additional predictors will help to establish their validity and potential usefulness in this domain.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- LEADERSHIP: Developing leaders in a changing army (WP 103);
- Accelerating Leader Development (WP 269);
- Accelerating Leader Development (WP 285); and
- SELECT21: Selection, Classification and Performance Metrics for the Objective Force (WP 257); ATO: IV.HS. 2002.01.

### **Overview**

The Army (and other organizations) must have leaders or potential leaders who continuously pursue the development of leadership skills and who are flexible and adaptable through their involvement in self-initiated development and learning experiences. The Army cannot rely solely on mandated training or learning experiences—it needs leaders or potential leaders to be motivated to pursue self-initiated development of leadership skills and characteristics. Total development must be motivated and initiated from within the person. But little is known about predicting leadership development behavior because most research has been directed at predicting the performance of leaders. Leadership development and leader performance are not the same thing. Likewise, motivation to be a leader and motivation to develop leadership skills are not the same. The Army needs a better understanding of leadership development and those behavioral constructs and assessment methods that are relevant to leadership development, especially those that involve individual sustained effort to develop leadership attributes. Basic research that addresses these issues can ultimately lead to applied research which enables better selection and development of leaders.



A key first step in this process is to develop behavioral variables/constructs and assessment methods, including a network of related variables, that would help establish the validity and relevance of these new variables in this domain. The variables will be explored within a system of related constructs, including antecedents and consequences, to establish the relevance to other variables within the leadership development domain.

There will be two general sets of variables examined in this research. The first set of variables includes variables being introduced here as new to the leadership domain. This set includes: motivation for leadership development, self-efficacy (or self-confidence) for leadership development, and beliefs about the improvability of leadership skills/attributes (e.g. beliefs that leadership can be developed vs. leadership is born). In addition, participation in leadership development activities for the purpose of learning/developing leadership skills also will be examined. The second set of variables to be examined are traditional personality variables, as well as selected variables from the employee development literature, that can be examined as predictors of these new variables.

In general, it is expected that hypothesized relationships of these leadership development variables with each other and with additional predictors will help to establish their validity and relevance in the leadership development domain. Constructs relevant to leadership development (e.g., self-efficacy for leadership development, motivation for leadership development) will be distinguished theoretically and empirically from constructs relevant to leadership performance (e.g., self-efficacy for leadership, motivation to lead).

It is hypothesized that (Hypothesis 1) self-efficacy for leadership development (SELD) will predict motivation to develop leadership skills (MTDL), and that (Hypothesis 2) self-efficacy for leadership (SEL) will predict motivation to lead (MTL). The corresponding self-efficacy constructs will have higher predictive validity for the corresponding motivational constructs (e.g.,  $SELD \rightarrow MTDL$ ;  $SEL \rightarrow MTL$ ). Hypothesis 3 is that leadership improvability beliefs (IBL) will predict SELD, and hypothesis 4 is that IBL will predict SEL, although it will have a higher relationship with SELD due to their closer conceptual relationship. Further, (Hypothesis 5,) MTL will predict MTDL, but this relationship will be greater for those individuals who have higher IBL. In other words, those who are motivated to lead also will be more motivated to develop leadership skills; however, this will be more true for those individuals who have higher beliefs that leadership skills/attributes are improvable/acquirable. Therefore, IBL will moderate the relationship between MTL and MTDL. Also, (Hypothesis 6), MTDL will predict participation in leadership development activities directly. MTL will only predict leadership development activities through MTDL and not directly; that is, MTDL acts as a mediator between MTL and leadership development activities.

In terms of the traditional personality variables, it is expected that openness to experience (Hypothesis 7) will have a relationship with motivation to develop leadership (MTDL) skills but not with motivation to lead (MTL). Prior research did not find a relationship between motivation to lead and openness. However, it did find a relationship between extraversion and motivation to lead, and so that is expected here (Hypothesis 8). In addition, it is expected (Hypothesis 9) that the traditional employee development constructs (e.g., self-perceptions that the person possesses the qualities needed for learning/developing, perceived need for development of one's own



skills, social support for learning/developing, perceived benefits of developing skills) will relate to the development-oriented constructs (e.g. motivation to develop, self-efficacy for development), but not motivation to lead and self-efficacy for leadership.

## **Research Approach**

A two-wave survey method will be used to collect data from participants. The source of subjects will be an on-line research pool through StudyResponse.com. As introduced at the 2003 annual meeting of the Society for Industrial and Organizational Psychology, StudyResponse is a service that matches researchers with participants willing to receive solicitations to complete surveys. Registered participants (currently  $N > 46,000$ ) have varied demographic characteristics including racial makeup, gender, education, and a varied list of occupations. Working adults of a wide range of ages will be included, which will allow the investigation to focus on both younger and more mature adults.

Administrators of this service did a benchmarking study recently by replicating the topic matter of a national poll conducted with systematic sampling by a large polling company. The researchers found that the results from the StudyResponse panelists' responses corresponded with the results obtained in the national poll of opinions within just a few percentage points of error on just about every question asked. This suggests that the results provided by this sampling approach are reasonably representative of data provided by traditional and systematic sampling/polling procedures. This Internet panel approach provides a viable approach as a sound sampling strategy.

The two sets of variables described above will be examined in the following way. First, the relationships among the leadership development constructs will be tested when data for the total set of these measures is collected in two time periods. By collecting data for these measures twice, this allows for a retest interval to examine the stability of the constructs across time and also for prospective prediction of some of the constructs onto others at a later time. For example, self-efficacy for leadership development at time 1 can be used to predict motivation to develop leadership skills at both time 1 and time 2. Likewise, motivation to develop leadership skills can be used to predict not only participation in leadership development activities at time 1 but also at time 2. So the relationships among the leadership constructs can be examined when the data are all collected at time 1. They can also be examined when the data are collected again at time 2 and the stability and prediction across time can also be tested.

The second set of variables (the traditional/existing constructs) will also be examined in relation to the leadership variables. These data will also be collected at time 1 and examined in relation to the leadership constructs at time 1, and also the leadership constructs that are measured again at time 2. This will also allow prospective prediction by some of the traditional constructs onto others at a later time. For example, personality can be used to predict self-efficacy for leadership development measured at both time 1 and at time 2.



## **Accomplishments**

In the first year (year 1 of a 3-year project), the literature was reviewed to determine the content of the newly prepared leadership development measures. Forty-seven leadership attributes were identified. These attributes will be used to collect ratings for leadership improvability beliefs, self-efficacy for leadership development, and motivation for leadership development. Corresponding and more generally-worded measures of leadership development/improvability (as opposed to the development/improvability of specific leadership attributes) were also created. These measures and the measures for the traditional/existing personality and employee development variables were then reviewed for wording, scaling, and formatting. Several iterations and revisions were done. A computerized/Web version of the measures was developed and reviewed, and the system was tested to ensure the accurate capture of responses from the survey to the database. A pilot investigation was then conducted to test the surveys and the data collection process. Over 271 participants responded to all parts of this pilot investigation.

In year two, the data from the pilot were analyzed and the instruments examined to determine if any modifications needed to be made to the measures and Web survey prior to the full data collection. In this pilot study, in addition to testing the measures and data collection procedure, we obtained some preliminary findings that nicely set up the full study that is yet to come. In the pilot study, motivation to develop leadership was empirically distinguished from motivation to lead. Detailed statistical and psychometric analyses supported the validity of the new leadership development motivational measures so far. The leadership development constructs predicted leadership development activity reports better than the leadership measures. Analyses further suggested that being attracted to leadership for special rewards or extrinsic reasons is unrelated to the motivation to develop leadership capability, while being attracted to leadership for intrinsic or social responsibility reasons is significantly related to motivation to develop leadership. Of three types of leadership skills (task, people, and transformational), transformational was rated most difficult to improve and participants were least motivated to develop those skills. The results of the pilot study will be presented at an international conference in April of 2007. Also in year two, after completing the pilot study analysis and determining that the measures and data collection procedure had integrity, we then initiated the full study data collection. The full study addresses predictors and outcomes of the motivational variables in a much fuller and detailed examination of the variables than in the pilot study, which was relatively limited and focused in nature. In the full study, our major hypotheses will be tested.

## **Contributions to Basic Science**

There has been a good bit of research on predicting leader performance. However, there has been relatively little research on predicting leadership development behavior. For example, while motivation to lead and self-efficacy for leadership have been explored in research, self-efficacy for leadership *development* and motivation to *develop* leadership skills has not. Also, especially given differing ideas about whether leaders are born or made, there may be differences in how aggressively and effectively potential leaders pursue the development of leadership skills. Successful development of leadership skills depends on strong motivation to develop these skills.



The current research will test a model of leadership development motivation that specifically targets motivation to develop leadership skills.

A recent research article (Ruvolo, Petersen & LeBouef, 2004, *Consulting Psychology Journal*) authored by officers in the U.S. Army is titled "Leaders Are Made, Not Born," which strongly reflects the notion that leadership can be developed. Further, there are many examples of successful leadership training and development programs. However, it is well known that people differ markedly on their beliefs that leaders are 'born or made.' Beliefs that leadership attributes are innate or fixed and are not acquirable or improvable might be a fundamental belief that can set the stage for someone's overall motivation for leadership development. To the extent that a person believes that leaders are born and not made, this can be a substantial impediment to optimal motivation for developing leadership skills. This research will explore this belief and the role that the construct plays in leadership development motivation. In addition, the similarities and differences between constructs associated with leadership performance and leadership development will be addressed conceptually and empirically. This includes the distinction between self-efficacy for leadership vs. self-efficacy for leadership development, and motivation to lead vs. motivation to develop leadership skills. Differences in the antecedents and outcomes of these constructs also will be explored to establish their distinct construct validity. These issues have not been explored previously in relation to leadership development but do have great theoretical and practical promise.

### **Potential Army/Military Applications**

Developing these new constructs in the leadership domain and establishing the construct validity of them in basic research could lead to applied research in key areas addressed by ARI. Generally, this applied research could fall into two categories: individual difference predictive studies and experimental research in which manipulations are used. First, these constructs and associated assessment methods, along with traditional predictors such as intelligence and personality, could be used as predictors of performance, motivation, development and adaptability in Army training and field settings. To the extent that these measures predict effectiveness in adapting to leadership roles and learning and developing necessary skills, these tools might be used in selection and placement within the Army to identify those individuals who will likely most benefit from leadership training and who are most likely to take initiative to continually develop and improve leadership relevant characteristics in themselves. These individual-difference constructs and assessment tools might be explored in applied research for relationships with key behavioral and performance criteria relevant to leadership and leadership development and learning in practical Army settings.

There is also a second way that developing these new constructs in the leadership domain in basic research could lead to applied research in key areas addressed by ARI. Research might be done on ways of influencing these constructs in Army personnel to improve motivation for leadership development. Variables such as self-efficacy are subject to enhancement through mastery experiences, persuasion, modeling or vicarious learning. Self-efficacy for leadership development might also be influenced through these types of tactics. For example, some research has manipulated expectations for military personnel and found effects for increasing self-efficacy. Applied research might be conducted to determine whether self-efficacy for leadership



development can be influenced, and whether this enhances motivation for development of leadership skills and subsequent development and performance. Prior research and theory suggests that this should be possible.

It also should be possible to conduct applied research on ways in which beliefs about improvability of leadership skills can be influenced. Prior research in settings not involving leadership and leadership development suggests that implicit theories of ability (beliefs about improvability of attributes) are susceptible to influence. It should be possible to determine if influences on beliefs about improvability of leadership skills have a subsequent influence on motivation to develop leadership skills and attributes as people increasingly believe that it is possible to develop and improve specific characteristics. Thus, to the extent that these constructs are developed and validated in this basic research, additional applied research could follow.

### **Future Plans**

In year three, the full data collection will proceed, and when complete, the full data analysis and interpretation will be done based on all data (time 1 and time 2) as described previously. A full research report of the findings along with measures and psychometric properties will be the outcome. Publication of this research in (a) scientific outlet(s) will be pursued.

## **Identifying Individual Attributes and Learning Principles that Foster Adaptive Performance and Promote Rapid Adaptability Skill Acquisition Through Multiple Modes of Development**

**Contract Number:** W74V8H-05-K-0004

**Institution:** George Mason University

**Contract Dates:** 01/15/2005 to 07/31/2007

**PI:** Stephen J. Zaccaro

**Liaison:** Robert Pleban, IFRU

**Problem(s)/Research Question(s)** – What training and development principles produce the most effective acquisition and growth of leader adaptability skills? What individual attributes moderate the impact of training and development interventions on adaptability skills, and what combinations of leader attributes and team processes lead to adaptive performance in today's military operational environments?

**Technical Barrier(s)** – Past theories and models of leadership and team training are inadequate for understanding how to develop adaptive leaders and teams. Training and developing adaptability skills for both individual Soldiers and teams requires learning strategies that are different from those traditionally employed by the Army.

**Significance/Impact for Basic Research** – The successful completion of this research effort should contribute significantly to the literature on leader and team development, in particular on strategies for growing individual and team level adaptability skills through formal instruction, developmental work assignments, and self-development. We should also add new information to the small but growing literature on leader attributes patterns and their influence on leader adaptive performance

**Potential Transitions** – The products of this research should provide the basis for applied research and application in various Army leadership training and development programs, such as those being conducted at Fort Benning and Fort Leavenworth. Other specific applications that can be explored through future potential DoD SBIRs may include:

- The development of formal training programs that target leader adaptability skills; and
- The refinement and validation of assessment tools that can be used in Army training and development activities to measure developmental work experiences, learning attributes, and adaptive performance processes.

### **Overview**

The overall purposes of this research effort are to expand current understanding about the nature of adaptive leadership, and to explore the most effective ways of developing adaptability skills through three modes of training – formal instruction, operational assignments, and self development. We build on prior research to explore the leader attributes that promote effectiveness as environment conditions become more dynamic and adversarial. The specification of adaptive leader processes and attributes sets the stage for a consideration of best practices in leader training and development to foster growth in leader adaptability. Accordingly, in this research effort we investigate training and development principles that are likely to



produce the most effective growth of particular leader adaptability skills. We also examine how these principles vary across different modes of Army leader development.

Prior theory and empirical research has supported the premise that certain forms of leadership communications, in the form of sense-giving and performance feedback, specifically process-oriented feedback, contributes to growth in adaptive performance. We are extending this research to examine the influences of a training design that incorporates (a) a problem centered approach that utilizes multiple and qualitatively different performance practice scenarios, and (b) strategies for enhancing the practice of metacognitive thinking and performance regulation skills. The overall purpose of these training strategies is to enhance the degree to which trainees engage in greater frame-switching processes when operating environments become more dynamic. We also are examining and extending these training principles in the context of different training approaches, including work experiences and self-learning strategies.

This research effort also includes an examination of leader attributes that contribute to effective adaptive leadership. These personal attributes include such qualities as cognitive flexibility, self regulation and metacognitive skills, social and emotional intelligence, optimism, tolerance for ambiguity, and resilience. Relatively little research has examined how these attributes are integrated and how such integrations are linked to the processes of leader adaptation.

## **Research Approach**

We have recently completed the second year of the project. In year one of this effort, we constructed an annotated bibliography of studies on adaptability. We found 74 studies to date and coded them for the type of method use, and the particular focus of analysis (adaptive performance, adaptability processes, adaptability attributes, training and development, and assessment tools). We also coded for level of analysis (individual, leader, and team). We found representative studies in all of our coding categories, with the fewest studies (10) on the assessment of adaptability. We also found that additional research was most needed on:

- Predictive validation of linkages in models of adaptability attributes, processes and performance;
- Validation of assessment tools; and
- Empirical examinations of training designs that focus specifically on the development of adaptability skills.

We are currently updating the bibliography and preparing a conceptual paper summarizing our full results. In the first year of this effort, we also completed an experiment that examined the effects of variability in training practice scenarios on adaptive performance in teams. Adaptability typically requires a process of “frame-switching” that results in new and different ways of examining problems. Accordingly, adaptability training should provide opportunities to practice such frame-switching. In this experiment, teams completed a decision-making task (SimCity4), in which they practiced solving a series of three problems. In one condition, groups received a series of problems in which all three required similar decision strategies. In another condition, groups received a series of problems in which each required a

qualitatively different decision strategy. Then all groups were given an adaptive performance trial that required decision strategies different from all previous trials. Groups were free to make as many decisions as necessary to solve the key issues in the adaptive performance trial. Possible decision solutions in this last trial ranged from low to high in their requirements for frame-switching. This research approach, then, tests the proposed association between one key training parameter, practice scenario variability, and team adaptability.

In year two of the research effort we completed another experiment (described below), initiated a third, and initiated several field studies. These are described in more detail below.

## Accomplishments

The data from Investigation 1 indicated support for the proposed hypothesis. As Figure 1 shows, the variable scenario practice condition resulted in greater numbers of overall decisions than the routine practice decisions, but the largest differences were on decisions reflecting greater frame-switching. The frequency of high frame-switching decisions was also significantly correlated with a key parameter of overall adaptive performance.

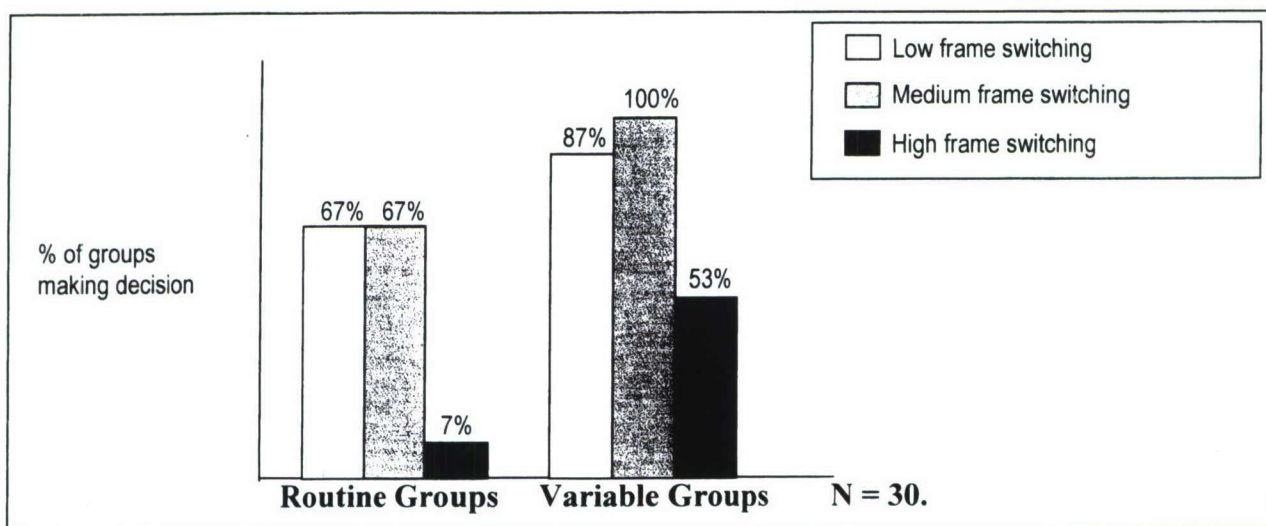


Figure 1. Decisions made by groups.

*Note:* Groups make multiple decisions during the adaptive performance test trial. These decisions vary in terms of whether they reflect low, medium, or high frame-switching. This figure shows that the largest differences between the groups were in the number of high frame-switching decisions made by group members.

We assessed several potential mediators to explain the effects of training practice variability on adaptive performance, including collective efficacy for dealing with change, and the accuracy and sharedness of mental models. Groups did not differ significantly on these variables, suggesting that the primary consequence of practice variability is to prompt the occurrence of more frame-switching processes during adaptation.



In the second year of this effort, we completed a second experiment that examined the role of adaptive self-regulation training in fostering effective frame-switching. In Investigation 1, all groups had received such training before beginning the practice trials. In Investigation 2, all groups experienced variability in practice scenarios, but only half of them received adaptive self-regulation training. In this study we found a pattern similar to Study 1 – groups receiving qualitative variability in practice scenarios showed greater adaptability in the test trial than groups not receiving such variability. This effect was somewhat moderated by the receipt of self-regulation training. Groups that received variable scenarios but no self-regulation training did not tend to exhibit the same degree of adaptability in the test trial.

Because this moderating effect was modest in size, we are completing two more studies, one with college students and the other with Soldiers at Fort Benning. Our focus is on sharpening the self-regulation training and examining in more detail the changes occurring in individual cognitive processes as these individuals encounter the variable scenarios under high and low conditions of adaptive self-regulation training. The results of these studies should shed some light on the role of both training parameters on cognitive processes linked to adaptive performance. We also are examining the role of individual differences in cognitive flexibility and metacognitive skills in moderating the proposed effects of training parameters.

In the second year of the project we also (1) completed construction of a survey that assesses qualities of work experiences proposed as contributing to growth in individual adaptability skills, and (2) completed the development of tools that can be used in self-learning programs focusing on leadership adaptability skills. We also developed a constructed-response assessment of adaptive decision making in complex and dynamic business scenarios. These instruments incorporate the basic principles of growing adaptability skills that are being examined in the laboratory studies. We are currently administering these instruments to managers in a variety of business settings to test the validity of these learning principles, as operationalized in developmental work assignments and self-development exercises. As part of these field research efforts, we also are administering measures of individual differences proposed as being associated with adaptability.

### **Contributions to Basic Science**

This research effort should provide substantial benefits by enhancing our understanding of how to train and develop adaptability skills through formal course instruction, as well as through officer assignments and self-development efforts. This research effort also should contribute to the growing literature on how different characteristics of leaders are linked in patterns to influence leader adaptive performance, as well as the leader's responsiveness to different training interventions.

### **Potential Army/Military Applications**

Some of the anticipated products of this research effort include training-based assessment tools and training protocols that can contribute to more effective development of Soldiers and officers. Several training units, including those at Ft. Benning and Ft. Leavenworth, are interested particularly in developing more adaptive leaders. We are using a computer-based training

simulation at Fort Benning to test our hypotheses. We have completed an initial round of data collection, and have been invited back to collect additional data. If our hypotheses are confirmed, our experimental design and reprogramming of some of the scenarios in the simulation have the potential of providing some direct applications for adaptability training to the BOLC programs offered at Fort Benning.

### **Future Plans**

We expect in the final year of this research effort to:

- Complete data collection and analysis of our third laboratory investigation with undergraduate students;
- Complete data collection and analysis for our investigation at Fort Benning;
- Complete data collection and analysis of surveys to business managers that measure the quality of leader work experiences;
- Complete data collection and analysis on the self-development study administered to direct marketing and sales managers; and
- Complete all data analyses and prepare research reports on each study, as well as a paper on the conceptual foundations of this research effort.



**BRU RESEARCH OBJECTIVE #3: PROVIDE FUNDAMENTAL  
KNOWLEDGE FOR IDENTIFYING, ASSESSING, AND ASSIGNING  
QUALITY PERSONNEL FOR THE EVOLVING ARMY**

Research in this section is directed toward identifying and measuring the aptitudes and skills that are unique to the human performance requirements of the Future Force. Exploring the sociological and psychological factors that could influence recruitment, retention, and Army performance are important aspects of this research objective.

## **An Interactionalist Analysis of Soldier Retention Across Career Stages and Time**

**Contract #:** W74V8H-04-K-0002  
**Institution:** Texas A&M University

**Contract Dates:** 06/01/2004 to 09/30/2005  
**PI:** Gilad Chen  
**Co-PI:** Robert Ployhart  
**Liaison:** Michael Rumsey, SARU

**Problem(s)/Research Question(s)** – How do personal, situational, and temporal factors help explain retention processes at different career stages?

**Technical Barrier(s)** – Models of retention have yet to consider dynamic processes leading to turnover, and whether retention processes might differ at different career stages.

**Significance/Impact for Basic Research** – Understanding how and why the decision to stay or leave an organization unfolds over time, and whether personal and situational factors differentially drive these processes at different career stages.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- RETAIN: Strategies to Retain Quality Soldiers (WP 271);
- Soldier Attitudes and Opinions in a Changing Army (WP 102); and
- SELECT21: Selection, Classification, and Performance Metrics for the Objective Force Soldier (WP 257) and ATO: IV.HS.2002.01.

### **Overview**

As a result of both the collapse of the former Soviet Union and the horrendous events of September 11, 2001, the U.S. has engaged in a series of conflicts around the globe, oftentimes simultaneously. In today's reality, and probably even more so in the future, the U.S. armed forces must be flexible and adaptable in their ability to deploy the same troops to qualitatively different types of conflicts, with vastly different purposes (e.g., dismantling terror and/or drug networks, homeland defense, peace keeping) and in different geographical locations. Consequently, the U.S. armed forces have put a high premium on selecting, training, and maintaining the sufficient human resources required for being competitive in this new global reality. Furthermore, effective retention has never been as consequential as it is today, given the high costs involved in attracting, selecting, and training Soldiers.

Unfortunately, current theoretical models of retention provide an insufficient basis for our understanding of retention in such complex and dynamic work environments. Our research addresses three limitations of previous retention research:

1. Organizations can enhance retention through management practices directed at creating more positive work situations, and through staffing practices directed at selecting employees who would better fit the work environment. Accordingly, the first contribution of the present research is the simultaneous examination of both person variables (cognitive ability) and situational variables (social support and work challenge) as



predictors of the retention process. In particular, we propose that *lower levels of ability and higher levels of social support and work challenge are associated with more positive levels of job attitudes, and thus lower likelihood of turnover*. We further consider possible person-by-situation interactions, and propose that *the relationships between ability and job attitudes are less negative when social support and work challenge are higher*.

2. There is now a growing awareness that factors that affect work experiences may vary across career stages, given that employees require and desire different things at different stages of their careers. In the context of the U.S. Army, for instance, there could be different reasons why first and second term Soldiers decide to re-enlist. At early career stages, Soldiers are adjusting to their new military career, and thus social support is particularly critical. However, at later career stages, Soldiers are more likely to appreciate and benefit from challenging work assignments. Accordingly, a second contribution of our research is the examination of whether retention processes are affected by different factors at different career stages. In particular, we propose that *cognitive ability and social support are more likely to relate to job attitudes and retention at earlier career stages, whereas work challenge is more likely to relate to job attitudes and retention at later career stages*.
3. Finally, given that employees in many organizations (including the U.S. Army) transition from one work environment or project to another quite frequently, it is critical to know whether such transitions are associated with changes in retention decisions as well as in proximal drivers of retention outcomes (e.g., job attitudes), and whether capturing particular patterns of change (i.e., growth/increase or decline/decrease) in variables capturing the retention process can help explain additional variance in turnover. In our research, we propose that *more positive changes in job attitudes are associated with decreased likelihood of turnover*. Moreover, we argue that changes in job attitudes capture a unique phenomenon different from average levels of job attitudes, and thus changes in job attitudes should account for additional variance in retention decisions over and above average levels of job attitudes.

## Research Approach

We tested our propositions using field survey data collected by Walter Reed researchers (called the OPTEMPO project) from over one thousand Soldiers at multiple times over the course of two years. The survey data were linked to Soldiers' ability scores, which were collected during the selection process into the U.S. Army. The surveys captured multiple aspects of the work environment, including social support (i.e., perceived quality of officer and non-commissioned officer leadership, co-worker support) and work challenge (i.e., job challenge, significance of work tasks, and whether Soldiers were in deployment, in training, or in their garrison base). At each time period, Soldiers also indicated their job attitudes (i.e., job satisfaction, job involvement, and general morale) and intention to re-enlist with the Army. Finally, career stage data also are available. These rich data are unique in that they allow us to capture and explain retention processes as they unfold over time, and at different career stages.



## **Accomplishments**

Results provided mixed support for the propositions. In particular:

1. First, although cognitive ability did not predict job attitudes or turnover intentions, situational variables (social support and work challenge) strongly predicted job attitudes, which in turn predicted turnover intentions. However, no interactions between ability and situational variables were detected. Thus, the results supported the relationships between situational variables and turnover intentions, as mediated by job attitudes, but cognitive ability played no role in these relationships.
2. Second, the data did not support our career stage propositions. Simply put, the results did not differ for Soldiers at different career stages, as measured by military tenure and rank.
3. Finally, our proposition that more positive changes in job attitudes are associated with decreased likelihood of turnover was largely supported. In particular, we found that Soldiers differed in the extent to which their job attitudes improved or got worse over time, and that those whose job attitudes improved more over time also indicated they are more interested to re-enlist with the U.S. Army for additional terms.

## **Contributions to Basic Research**

This project contributes to the employee retention literature in several important ways. First, by integrating person and situation theories of employees retention, this research provided a more comprehensive picture of the retention process and its determinants. Second, this research suggested that drivers of retention do not seem to differ across career stages, and thus practices and principles for retaining employees are likely to generalize across career stages. Finally, moving beyond the mostly static retention research, this research provided a richer, more dynamic view of how and why employees' decisions to stay or leave the organization evolve over time vis-à-vis their experiences at work. In particular, we showed that employees' decision to stay or leave the Army change over time, and corresponds to whether their job attitudes improve or get worse over time.

## **Potential Army/Military Applications**

This research has the potential to advance Army/military applications in several ways. First, given that U.S. armed forces' selection systems rely heavily on cognitive ability, it is important to ensure that more-qualified Soldiers (i.e., those higher in ability) are those remaining in the military. Failing to find reliable relationship between cognitive ability and the retention process is, in a way, good news; it suggests selecting Soldiers based on cognitive ability will not be likely to affect retention rates (while, at the same time, help promote the high level of performance associated with ability). Second, our results that predictors of turnover, particularly job attitudes and situational variables, do not differ at different career stages suggest that the same practices directed at retaining Soldiers can be effective at different career stages. Finally, given that this investigation tracked Soldiers over the course of 2 years as they transition across



different work assignments (i.e., training or deployment), it helped to better explain the decision process associated with retention.

In particular, our research showed that, over time, Soldiers' experiences and attitudes are shaped by social support and work challenge, and, as these experiences and attitudes improve or get worse over time, so does the likelihood Soldiers would leave or stay with the military. As such, our research suggests that leaders need to *continuously* support and assign challenging and interesting work tasks to their Soldiers, as doing so would likely help improve their job attitudes and thus increase the likelihood of retention. Altogether, this research will likely help the military improve various management programs directed at enhancing retention, and help align these programs with the military's staffing strategies.

### **Final Summary**

The results of our study have several implications for how staffing and managerial practices relate to Soldiers' decisions to reenlist with the U.S. Army. First, Soldiers' cognitive ability did not relate to Soldiers' job attitudes (work-related morale, satisfaction, and psychological involvement) and reenlistment intentions. These findings are promising in as much as they suggest that reliance on ability testing in selecting recruits into the Army would unlikely in and of itself lead to lower levels of morale, satisfaction and reenlistment rates. Second, we found that social support and work challenge variables positively promoted job attitudes, and that job attitudes, in turn, positively related to reenlistment intentions. These results suggest that leadership and work design practices that enhance social support and job challenge can motivate Soldiers to reenlist with the Army, because they promote more positive work attitudes. That is, leaders should motivate Soldiers by simultaneously challenging and supporting them. However, our final set of findings suggest that, the extent to which job attitudes improve over time also plays a role in whether or not Soldiers intend to reenlist. These results imply that leaders should ensure they continuously strive to improve Soldiers' morale, satisfaction, and involvement, to enhance chances of Soldier reenlistment.

## Measuring Average Speed of Numerical Reasoning

**Contract #:** 1435-04-03-CT-74083  
**Institution:** University of Minnesota,  
Twin Cities

**Contract Dates:** 10/01/2003 to 07/31/2006  
**PI:** Mark L. Davison, Ph.D.  
**Co-PI:** Robert Semmes  
**Liaison:** Michael Rumsey, SARU

**Problem(s)/Research Question(s)** – Is time-constrained performance within a given cognitive task domain determined by one ability, called *level* of performance, or by at least two abilities, level of performance and *speed* of performance?

**Technical Barriers** – (a) Undeveloped theory of the cognitive abilities responsible for time-constrained performance of tasks having non-trivial difficulty; and (b) the absence of valid models and procedures to measure speed of performance of cognitive tasks having non-trivial difficulty.

**Significance/Impact for Basic Research** – If our project is successful, we will report the first psychometrically valid method for measuring average speed of performance of cognitive tasks having non-trivial difficulty. Moreover, the most widely accepted model of the structure of cognitive abilities (Carroll, 1993) will need to be revised.

**Potential Transitions** – This research could potentially lead to:

- Improved measures of key attributes that Soldiers need for effective performance in assignments for which mental quickness *and* accuracy are important;
- Enhanced predictive validity of the Armed Forces Qualification Test (AFQT), if that test were modified to measure performance speeds in each of the cognitive domains it assesses;
- Performance scores that can be used in a model that matches persons to jobs (i.e., improved methods for classifying and assigning force members); and
- Improved training programs in areas where mental quickness and accuracy are critical.

### Overview

Few would doubt that if each person in a group were assigned a set of non-trivial cognitive tasks of like kind, then people would vary in how successfully and rapidly they performed those tasks. Psychologists have known for several decades how to measure validly a person's ability to successfully perform a set of non-trivial tasks from a narrow cognitive domain (e.g., spatial visualization and inductive reasoning)—provided task performance is self-paced. Relative to a given cognitive task domain, that ability is called *level*.

On the other hand, there currently does not exist a valid way to measure how quickly a person successfully performs a set of non-trivial cognitive tasks when strict time-limits for task completion are imposed. Few psychometricians appear to be aware of this methodological gap, or even aware that in a given cognitive domain a quickness or *speed* ability might exist and be measurable. In part this may be because none of the several dozen (rarely cited) studies conducted in the 20<sup>th</sup> century to measure domain-specific speed abilities were successful.



Those previous attempts to measure speed abilities in specific cognitive domains failed primarily because investigators used faulty measurement models. For example, many investigators employed speed scores that were some function of a person's collective item response times (e.g., mean, median, or total). That approach, however, ignores the likely influences that varying item characteristics have on item response times, much as they do on binary item scores (right and wrong scores). Some researchers who used this approach also used both right and wrong answer times when computing speed scores, and thereby assigned speed scores confounded by extraneous variables such as time taken to guess answers and time taken to consider and then abandon items. Other researchers tried to adapt classical test theory's true-and-error score model to the measurement of speed. But that model—which was the dominant psychometric model for most of the 20<sup>th</sup> century—was, *a priori*, ill-suited for measuring hypothetical speed ability. The true-and-error score model postulates that a person's success or failure on a cognitive test item, regardless of the conditions of performance, is a function of only one ability, the person's so-called *true score* in the given cognitive domain.

In this study we will use modern measurement models in an attempt to measure an average speed ability in the domain of numerical reasoning. More formally, we will test what we call the *speed-level hypothesis*: in narrow cognitive task domains, two abilities—speed and level—determine a person's success or failure in time-constrained task performance. Our null hypothesis is that level ability alone determines a person's success or failure in both time-constrained and self-paced task performance.

## **Research Approach**

We are conducting a laboratory study wherein we have tested a large sample of University of Minnesota college students under two performance conditions, self-paced and time-constrained (“speeded”).

Using numerical reasoning test items drawn from old, published editions of the SAT and GRE general tests, we constructed two equivalent test forms. Students were randomly assigned to take one or the other form in a self-paced test session, and then returned one or more days later and took the alternate test form in a speeded test session. This procedure in effect generated two, independent samples of students. In the speeded session, each test item bore an assigned time-limit. Each item's time-limit was set to the median correct response time computed for the given item using the self-paced test data of a large initial sample of students. In both the self-paced test session and the speeded test session, test items were administered one at a time using a personal computer. Each student's test sessions were conducted individually in the seclusion of a relatively sound-proof room. During each session computers recorded the student's answers and answer times.

To each of the two samples' self-paced test data we will fit a measurement model that postulates that a single ability, level, accounts for students' binary item scores (right or wrong scores). The fitted models will furnish us an estimate of each student's numerical reasoning level ability.



The centerpiece of our data analysis consists of our comparing the fit of two competing measurement models to our subjects' item scores earned during the speeded test sessions. One of the models will have the same structure as the one fitted to the self-paced data, and will incorporate each student's already-estimated level ability. The other measurement model postulates that two abilities—level and average speed—account for students' speeded item scores. We will confirm our speed-level hypothesis if we find that the two-ability model provides the better fit to the item scores earned during the speeded test sessions.

## **Accomplishments**

Based on our data analyses to date, the evidence for the speed-level hypothesis is mixed. We have found that in only one of our two subject samples are item accuracy scores earned during speeded testing unambiguously a function of two person attributes, one which is level ability, and the other which almost certainly is an average speed ability. Apparently our rule for setting item time-limits—for a given item, the median correct response time computed using the self-paced test data of an independent sample of students—resulted in time-limits for one of our samples that were too generous to elicit a detectable average speed ability. To measure an average speed ability in numerical reasoning by modeling the binary item accuracy scores of persons who vary widely in level ability, one should set at least some item time limits *very* low—perhaps as low as the 10<sup>th</sup> percentile of the self-paced correct response times recorded for the item using an independent subject sample.

Modeling correct answer times, rather than binary item scores, may prove to be a more fruitful approach to measuring speed ability in a given cognitive domain. Because answer times are measured on a continuous rather than discrete scale, and because all who correctly answer a given item will inevitably differ in their answer times, correct answer times contain far more information about a person's speed of performance than do binary item scores. Using data from one of our samples, we have successfully fit a speed-and-level model to 40 students' correct answer times to four relatively easy items that all 40 students answered correctly. Using the fitted model, we assigned speed and level scores to each of the 40 subjects. Subsequently we found that those students' speed scores, in linear combination with their level scores, performed better than level scores alone at predicting the percentage of 48 test items that the subjects correctly answered during speeded testing. There is, however, a difficult technical barrier encountered when modeling correct answer times. If some item time-limits are short, every subject will miss at least some items during speeded testing. Speeded testing thus generates a varying number of missing correct answer times for each subject and each item. Because correct answer times are not missing at random, in order to reliably estimate each subject's speed ability, one must first statistically impute each subject's missing correct answer times. The methodology for such imputation is very new, and there is no assurance that a statistically defensible way to estimate the missing correct answer times can be found.

To our surprise, in both of our subject samples we identified about a dozen students who correctly answered a higher percentage of items during speeded testing than during self-paced testing. Though there are other possible explanations for this phenomenon, perhaps for these students the challenge of solving numerical reasoning items bearing time-limits boosted their motivation to succeed over that which they experienced during self-paced testing. The existence



of such subgroups of people, although they are few in number, suggests that, at least in the task domain of numerical reasoning, relying solely on a person's level-ability score could well lead to erroneous conclusions about the person's actual capabilities.

### **Contributions to Basic Research**

If we are able to confirm the speed-level hypothesis in the numerical reasoning domain, then: (a) we will be the first researchers to have validly measured a person's speed of performance on a set of cognitive tasks having non-trivial difficulty; (b) we will have demonstrated that, within a given task domain, the conditions of task performance can strongly influence what cognitive abilities are measured; (c) we will have found a method to more completely and accurately summarize a person's proficiency status within the domain of numerical reasoning, and if so, we expect that our approach would likely generalize to other cognitive task domains; and (d) we will have presented strong evidence that the structure of human cognitive abilities is much more complex than is portrayed by the most widely accepted factor-analytic models (Carroll, 1993; Gustafsson, 1984); those models are based on global-time-limit test scores, which confound level ability with any speed ability that may exist for a given cognitive domain.

### **Potential Army/Military Applications**

Quickness and accuracy in problem solving under emergency or combat conditions is a highly desirable attribute of any person serving in a command or key technical role in the Army. The desirability of this attribute increases in proportion to the pace at which technology increases the volume and speed of communications. However, none of the four subtests that comprise the Armed Forces Qualification Test (AFQT) provides a measure of performance speed in any of the domains the AFQT assesses. Rather, all four parts are intended to be tests of power (Russell, Peterson, Rosse, Hatten, McHenry, & Houston, 2001, p. 77). Having recruits' speed scores in addition to their level scores could lead to important improvements in matching recruits to job specializations, particularly in cases where those persons would need to be able to perform complex cognitive tasks not just successfully, but rapidly as well.

### **Future Plans**

Our future plans include the following:

- Construct validate speed and level scores generated by factor analytic models. In particular, compare level and speed scores estimated by modeling binary item scores with those estimated by modeling correct answer times.
- Separately fit a so-called 2PL IRT model, designed to measure level ability, to item accuracy scores obtained from self-paced testing and then to item accuracy scores obtained from speeded testing. Next, compare the ability estimates derived from the two testing conditions. If the speed-level hypothesis is correct, then the two sets of ability estimates will not be linearly related.

- Investigate the concurrent validity of subjects' speed and level scores by fitting regression models to subjects' college admission ACT Math scores.
- Investigate imputing missing correct answer times in both samples' speeded test data. If overcoming the statistical complications entailed by this effort appear too time-consuming, we will postpone this research until after we submit our Final Report.
- Estimate the association between numerical reasoning speed and level scores with gender, handedness, and English as a second language.



## **Modeling the Strategic Role of Basic Emotions with Cellular Automata**

**Contract #:** W74V8H-05-P-0005

**Institution:** State University of New York,  
Oswego

**Contract Dates:** 01/01/2005 to 04/31/2006

**PI:** Craig DeLancey

**Problem(s)/Research Question(s)** – Under what conditions are emotional behaviors that in the short term may appear irrational (particularly retribution in anger and flight in fear), rational or beneficial for an individual or his or her group?

**Technical Barrier(s)** – Ethical and technical difficulties, along with prohibitive costs, create significant impediments to human subject research that induces and observes anger, fear, and other emotions in controlled situations.

**Significance/Impact for Basic Research** – The research provides both a model and a new explanatory framework to help us understand how some complex emotional behaviors evolved and how they can be beneficial or detrimental in both individual and social contexts. This can provide predictions for practical, more focused human subject research.

**Potential Transitions** – Knowledge to be gained in this basic research may be usefully employed in studies including but not limited to:

- ATO III.HS.2004.01 – Accelerating Leader Development (WP 269 & 285);
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103); and
- Assessing and Developing Leaders for Special Operations Units (WP 218).

### **Overview**

The goal of this research is to develop a model of the minimal conditions for certain kinds of emotional behaviors—particularly flight in fear and retribution in anger—to arise in a social group and to be beneficial for an individual or for that group. The model also makes predictions that can be tested in future empirical research, including empirical research with humans.

Emotions often motivate behaviors that are essential for our survival, but sometimes they can lead to behaviors that appear irrational. Some of these seemingly irrational behaviors may in fact be irrational, but others may be behaviors that on balance benefit us if we understand them in the right context. We have as of yet little ability to distinguish these cases, or when they are likely to happen. Important tools for predicting and evaluating the decision making of individuals have been developed in economics and related fields of inquiry. In general, these tools are based on the assumption that individuals are rational agents who evaluate the expected outcome of their available choices, and then make choices that lead to their most immediate expected benefit. However, actual empirical research into human decision making reveals that there are common and consistently-occurring forms of behavior inconsistent with a simple interpretation of these kinds of theories.



An early and surprising result of experimental economics was the discovery of an unpredicted and seemingly irrational behavior in Ultimatum Games that appears to be caused by anger or another retributive affect (Roth, 1995). An ultimatum game is a situation in which one individual (the “proposer”) is given some utility (typically money) and that agent must decide how to share this utility with another agent (the “receiver”). The receiver has no say in the distribution, but can decide to “veto” the offer, resulting in neither individual getting anything. Traditional economic and game theoretic models predict that the receiver will never exercise veto, but will rather accept any offer greater than zero, since something is better than nothing; and predict that the proposer agent, knowing this, will always distribute as little positive value as allowed in the game, and retain the rest.

However, in actual experimental tests with human subjects, the veto is frequently used by receivers in response to low proposals, and proposers typically offer nearly even division of utility—even in one-shot anonymous interactions. Thus, it appears that people often prefer less utility for themselves in order to punish others whom they perceive as making unfair distributions; and it appears that others know this and plan accordingly. One interpretation of this behavior is that individuals in the role of the receiver undertake retributive behaviors because they are angry. It is a likely hypothesis that such behavior may be rational in the long-term if it tends to enforce more equitable distribution for either that individual or his or her kind or offspring. Similar kinds of seemingly irrational, but rational behaviors may arise from fear.

The general notion that emotions have a special role to play in strategic action has received growing confirmation in a range of other sciences. Neuropsychological studies of ultimatum game performance have confirmed the role of brain substrates of emotion in ultimatum games and other kinds of games (Sanfey et al., 2003; Montague and Berns, 2002). Emotional deficits arising from brain damage have been identified that result in poor gambling and strategic choice behavior (Anderson et al., 1999; Bechara et al., 1994). The neural substrates of fear have become well understood (Panksepp, 1998, LeDoux, 1984), and the effect of fear on attention and other capabilities required for decision making are increasingly being investigated (Bishop et al., 2004).

However, progress in psychology and neural sciences fails to address two important features of the role of emotions in strategic action. First, existing models typically have no way to account for a benefit of emotional behaviors that stretches across games, or that influences the social context that in turn determines the structure of future games. For example, one utility of retributive behavior may be to enforce social conventions (such as fairness in various distributions) that benefit on average the individual in question. Exploring such a possibility requires some modeling of social interactions over both a range of games, but also in a context where behavior shapes future interactions. Second, there is insufficient attention to the complex social interactions that such emotions may require. We may need to explain the role and utility of a basic emotion in an agent’s action not only in terms of how it may have utility to the agent either immediately or by helping to maintain certain social conventions from which the agent benefits, but also in terms of how the display of the emotion affects other agents.

Experimental conditions and existing models are not yet able to address such possibilities. Furthermore, we cannot expect psychology or neural sciences to explore these



problems in the near term with animal-subject experiments or human-subject experiments, because the requirements of appropriate experiments are prohibitive. It is very difficult to induce fear, anger, and other emotions reliably and with controlled and significant intensities in subjects. It is even more difficult to induce such emotions in only selected subjects in groups. Finally, it is cost-prohibitive to generate sufficient test cases to control for the large error one can expect in subject interactions because of their inherent complexity. For these and other reasons, the strategic role of basic emotions will remain intractable to human and animal experiments for some time to come.

## **Research Approach**

The project uses a technique called genetic algorithms to develop and test possible strategies that simple agents may use in a range of games or simple strategic situations. This technique allows for the evolution of solutions to very complex problems. In this technique, strategies compete with each other, and how well a strategy does in comparison to other strategies determines how likely that strategy is to have “offspring”—that is, be the model for future identical or slightly altered strategies.

The problems answered in this case were concerned with when it is beneficial to adopt flight or retributive behavior even when such behaviors appear inconsistent with our standard notions of rationality. A series of hypotheses about the conditions for the evolution of such behavior were tested against various games (strategic situations) and various capabilities for the agents.

We also introduced a new explanatory model into evolutionary game theoretic explanation. We considered the possibility that agents might confront different types of games that include similar kinds of interactions, and that an agent might develop a strategy for a game that has highest overall benefit and then apply this strategy to other similar games. This form of explanation provides an especially compelling form of explanation for human performance in the Ultimatum Game.

## **Accomplishments**

Our simulations confirmed our hypotheses that retributive behaviors that lack short term benefits can evolve (win out as strategies against other alternative strategies) in a population of interacting agents.

Our primary model is a reputation-building model of altruistic retribution, which we call the “Reputation Game.” In this model, simple agents interact with each other playing games of distribution. Each agent has just five parameters. Four of these parameters are coded as five-bit binary strings, interpreted as representing values of 1-32 with standard binary interpretation (and the addition of 1). Each of these four parameters freely evolved (that is, the first generation had random values for each bit value for each individual, and then each generation is allowed to compete to have “offspring,” using standard genetic algorithm approaches of sexual reproduction with mutation). These parameters are: primary proposal, rejection-count threshold, secondary proposal (these three parameters apply when the agent is a proposer), and minimal acceptable



proposal (the sole relevant evolving parameter when this agent is a responder). The fifth parameter is the rejection count, which is a simple integer: this value begins as zero, and during a mock game play phase of thirty-two games as a responder, this value is incremented each time an agent rejects an offer. This can be thought of as the agent's reputation, announced at the beginning of a round, when the agent is playing the role of responder. During the actual game play phase, games are played by each agent as a proposer, against some randomly selected other agents in the population. In each game, the proposer can see the rejection count of the responder. If the responder's rejection count is greater than the proposer's rejection-count threshold, the proposer will use his or her secondary proposal. Otherwise, the proposer uses his or her primary proposal. This proposal is then communicated to the responding agent. When playing as a responder, the agent will reject any offer not greater than or equal to that agent's minimal acceptable proposal value.

This simulation evolves a stable strategy of both offering and expecting more equitable distributions in the Reputation Game. Figure 1 shows the mean population primary and secondary proposal values for 5,000 generations, normalized to range from 0 to 1. The typical population, after 300 generations, has both mean primary and secondary proposal values of 28% of utility. The population mean minimal accept value settles near 21% of utility.

The simulation confirms that a reputation for punishment leads to a more equitable distribution of utility in games played with those who have a reputation for retribution, but it also shows that primary proposals (those made to agents without a reputation for retribution) also evolve in the population towards more equitable distributions in line with human performance. A simplistic expectation for the simulation might be that agents will evolve the lowest possible primary proposals, but higher secondary proposals. This way, they could make equitable proposals to retributors but low proposals to those without a reputation for retribution. Instead, the population means for both the primary and secondary proposals quickly evolve towards a more equitable value. As agents begin to evolve high secondary proposals, it becomes in the interest of agents to develop a reputation over time for rejecting low proposals. This creates the opportunity for there to be offspring with higher minimal accept values. This also in turn creates a general environment where offspring are facing fewer low proposals; so many agents with higher minimal accept values will not reject many or any proposals and will not then develop a reputation for retribution (their rejection-count will be low or zero). The result is that reputation building helps not only agents that reject frequently but also benefits the entire population. The reputation for rejecting low proposals, in other words, starts to cast a halo over the whole population, as even those with very few or no rejections come to have higher accept values and other agents make higher primary proposals because their ancestors found it beneficial to avoid rejections. Agents have an "interest" in testing the rejection threshold of other agents, and this explains the wide standard deviation.



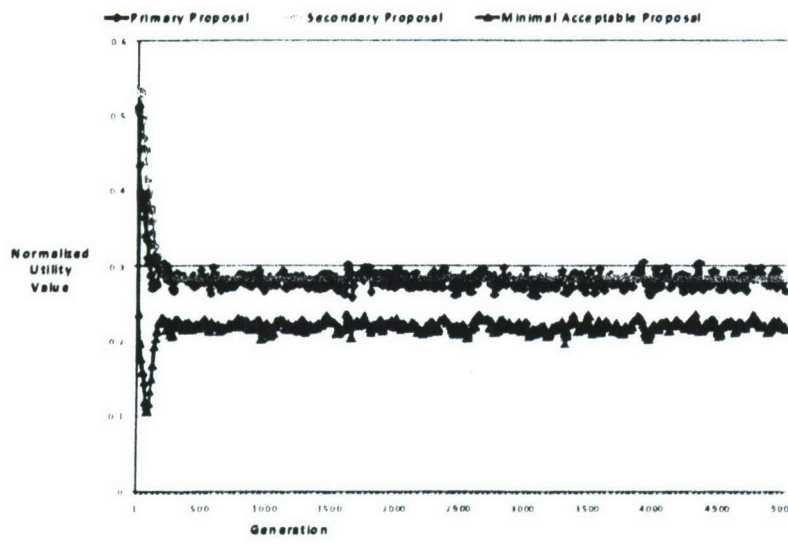


Figure 1. Population mean values for Reputation Game.

Our hypothesis is that an Ultimatum Game could be seen as a kind of approximate instance of this Reputation Game. The Reputation Game is one shot but not anonymous; an anonymous interaction is an interaction where the proposer knows nothing of the responder's rejection history. If we interpret this as the anonymous responder having, from the perspective of the proposer, a rejection history of zero (or, alternatively, *any* rejection history), then the proposer will be offering a mean value around 9 out of 32. This is 28% of the utility. Camerer's summary of Ultimatum Game findings shows a mean proposal typically ranging from 30% to 40% (Camerer, 2003). Furthermore, the population mean minimal acceptable proposal value tends towards 21% of the utility. Camerer's summary found that offers below 20% were rejected about half the time, whereas offers closer to 40% were rarely rejected. Thus, if we interpret Ultimatum Game performance as an application of the dominant Reputation Game strategy to the Ultimatum Game, these findings are close to human performance.

This model has on its side both plausibility and parsimony. It is plausible that human beings and their ancestors often interacted with the same individuals in non-anonymous situations, and that reputation building can play a role in the social benefits of retribution, so that something like the Reputation Game is more common and more important to humans than the Ultimatum Game. The strategy that agents use in Ultimatum Games would thus be a strategy that evolved or developed in response to something like Reputation Games; then this strategy is applied in Ultimatum Games because Ultimatum Games can be interpreted as an instance of Reputation Games. That is, there is a strategy in the Reputation Game that can be interpreted as a strategy for an Ultimatum Game—in our case, interpreting the lack of retribution history as



equivalent to a retribution history of zero (or any arbitrary value). Thus, the model can offer an explanation of human Ultimatum Game performance with no additional hypotheses.

Our explanation of human Ultimatum Game performance thus introduces a novel principle: the interpretation of a game as an instance of a more common game for which the agent has an existing strategy. The kind of evolutionary game theory explanation simulated here is neutral regarding whether it describes a strategy that is inherited or culturally transmitted, but depends upon the presumption that agents acquire and retain a strategy in a way resistant to immediate learning. The ancestors of human beings lived in socially rich environments where most strategic interactions were with known individuals with whom one was likely to interact again in the future. It is for this reason that we assume that the Reputation Game is much more representative of a typical human interaction than is an Ultimatum Game. The model is neutral regarding whether the evolution of the strategies is realized through inherited structures, or cultural transmission of behaviors, or any other form of transmission. Rather, all that is supposed by the model is that strategies are repeated and variations of them attempted, and the strategies that are reproduced tend to be those that beat out other strategies. Consistent with this form of explanation, once a strategy is adopted by an agent, it may be the sole strategy that the agent uses throughout all game play in the Reputation Game and similar games or approximate instances. That is, there is no reason to suppose that the evolution of strategies is occurring within any particular agent; the more simple application of the model is that each agent is using one strategy. This allows the model to explain behavior in various instances: Immediate learning is not a factor in the explanation.

This explanation is consistent with a growing body of evidence concerning human emotions. An important feature of anger and other motivations is that many of our emotions appear revision resistant; that is, unlike the kinds of preferences that economists typically study, they cannot easily be altered. For this reason a number of economists have argued that emotions can act as special commitment mechanisms, enforcing behavior that would otherwise be less likely to occur (Frank, 1989; Hirshleifer, 1984). Consistent with this, neural scientists have uncovered a growing body of evidence that some emotions and other forms of preferences are significantly independent of our abilities to consciously process information (Zajonc, 1968; Kunst-Wilson and Zajonc, 1980; Öhman, 1988; Öhman et al., 1989; Öhman and Soares, 1993, 1994). An inherited pancultural disposition could behave in this way, and remain, because its resistance to revision was not harmful or was even beneficial. Finally, many species of organisms have invested significant resources into the ability to display threats, suggesting that the role of making credible threats is an important survival skill. Organisms find it worthwhile to expend energy to create displays meant to convey their ferocity and willingness to fight. Lions growl, dogs bare their teeth, birds inflate themselves to exaggerate their size, and so on. These displays may be interpreted as attempts to create and convey a reputation of being willing to retribute, avoiding some conflicts but also in some cases perhaps earning more equitable treatment from other conspecifics. These findings are consistent with the idea that anger acts as an inherited disposition to retribute, that we benefit from communicating this disposition, and that we may act on this disposition even in cases where the benefits of reputation are lost because the disposition is not easily revised or controlled.



## **Contributions to Basic Science**

The project provides a new model of altruistic retribution and extends standard game-theoretic or decision-theoretic approaches. The interpretation of the primary model suggests several new areas for future empirical human subject research. First, the model of retributive reputation building predicts that over very many anonymous interactions, less equitable distributions of goods would come to dominate. This could be tested empirically. Second, the model predicts that certain forms of rational control of emotion (those inconsistent with the primary inherited function of the emotions) will be difficult, and this is because of a biologically inherited resistance to reason that is beneficial to the individual. Finally, the model introduces a novel explanatory tool for evolutionary game theory: the interpretation of a game as being an instance of a more common and general game.

## **Potential Army/Military Applications**

These results suggest that fear and anger must be recognized as inherited strategies in order to be effectively managed. These basic emotions resist rational control not because they are some kind of biological left-over which has not become amenable to our rational abilities—as if they were a kind of appendix of the mind. Rather, they resist rational control because it is part of their essential benefit to do so. This benefit is seen in at least two ways.

First, short-term and seemingly irrational behaviors that signal and establish a reputation for retributive anger can be an important way to make credible threats. It is necessary, that is, for anger to resist reason in order for it to allow certain kinds of credible threats. The same is likely true of fear also. For example, fear could serve to allow an individual to make credible threats of defection even in the face of serious (deferred) penalties.

Second, anger and fear may have a natural inherited tendency to resist rational control for the very reason that fitness and rationality can diverge. It might be irrational, given someone's beliefs, to avoid a dangerous situation (e.g., he or she may sincerely believe that some action is more important than the expected threat to his or her life the action will cause), but it may still be biologically fit for that person to avoid the action. Thus, for example, fear may in part resist rational control because this has been sufficiently fitness improving.

Recognizing these facts can ensure that it is understood that these emotions are inevitable, and cannot be managed through direct rational argument. Rather, these are inherited strategic benefits that must be considered as universal elements of human social interaction between groups and between individuals within a group.

## **A Valid, Culture-Fair Test of Intelligence**

**Contract#:** W74V8H05K006

**Institution:** Case Western Reserve University

**Contract Dates:** 11/15/2004 to 12/31/2006

**PI:** Joseph F. Fagan

**Liaison:** Peter Legree, SARU

**Problem(s)/Research Question(s)** – Can a racially unbiased test of the ability to process information predict how well young adults will succeed in college classes?

**Technical Barrier(s)** – Current theories of intelligence are based on an assumption that all those taking IQ tests have had equal opportunity for exposure to the information being tested. Thus, past efforts to develop an intelligence test that is culture-fair have not been successful.

**Significance/Impact for Basic Research** – The present study provides further evidence to evaluate a theory that defines intelligence as information processing ability (Fagan, 1992, 2000). Specifically, how much you know (your IQ) depends not only on how well you process information (your intelligence) but also on the information given to you by your culture to process. Current research on a theory of intelligence as information processing finds racial differences in IQ to be due to cultural factors. A test of information processing promises to be the first valid, culture-fair test of intelligence.

**Potential Transitions** – The results of this research will aid in gaining the objectives of:

- The Army's Science and Technology Objectives (STO IV. SP. 2002.02 and DTO HS.52 and WP 111) as to Training of Future Combat Commanders and Staff;
- The Army's Science and Technology Objectives (STO IV. SP. 2003.06 and WP 215) for Future Force Warrior Training;
- The Army's Science and Technology Objectives (STO IV. SP. 2002.01 and DTO HS.54 and WP 104 and WP 257) as to Selection, Classification and Performance Metrics for the Objective Force; and
- ARI's Work Programs on Leadership (WP 103, 211, 218, 269, and 285).

**Correspondence to the Aims of the ARI Basic Research Program** – This includes:

1. The general purpose of the present contract is *to add fundamental knowledge to behavioral science...and to discover general principles...[through an] integrated programmatic effort to develop and to test theory* (as called for by BRU in BRO-BAA, page 1).
2. The specific goal is to discover the relationships among information processing ability and knowledge that lead to achievement and productivity in complex situations. The goal is in keeping with the Army's goal to improve its ability to *Select, classify, train, and/or develop Soldiers and leaders who...are adaptable...[and who]...can function effectively in...information rich...environments* (BRO-BAA, page 1, II, 1, a, b).



3. One of the BRO-BAA Basic Research Areas of Interest is *leadership skills*. The proposed research will aid in the goal of identifying *Leadership skills in Adaptability...when faced with novel situations* (BRO-BAA, page 4, III, C, 1).
4. The research has resulted in a reliable, valid, and culture-fair test of intelligence based on the ability to process new information. The research aids in further demonstrating that *intelligence is a function of an aptitude* [learning ability in novel situations] *that cuts across domains and how to develop a method for measuring this aptitude* [and to further] *validate* [this] *cognitive ability against relevant criteria*, i.e., academic achievement (BRO-BAA, page 5, III, D, 1).

In summary, the research is in keeping with the Army's goal to select Soldiers and leaders who can function effectively in information rich environments (BRO-BAA, page 1, II, 1, a, b) and to identify leadership skills as to adaptability when faced with novel situations (BRO-BAA, page 4, III, C, 1). The proposed research will further aid in demonstrating that intelligence defined as learning ability in novel situations is an aptitude that crosses domains, and in validating this cognitive ability against relevant criteria (BRO-BAA, page 5, III, D, 1).

## Overview

The present study is based on a theory (Fagan, 1992, 2000) that assumes that we act on the basis of what we know and that what we know is a result of our processing of the information provided to us by our culture. Based on these assumptions, the IQ score is seen as a measure of knowledge. Specifically, how much you know (your IQ) depends on how well you process information (your intelligence) and also on the information given to you by your culture to process. The theory has been used to explain the source of IQ differences between Americans of different races. Specifically, we have found (Fagan & Holland, 2002, 2003, 2004) that American Whites and African-Americans who differ in IQ do not differ in their ability to process information when that information has been equally accessible to both groups.

## Research Approach

College students are given multiple choice tests of their ability to acquire new information concerning the meanings of previously unknown words, sayings, similarities, and analogies. They are also tested for their knowledge of vocabulary in general, opposites, and analogies. An entire session (training and testing) lasts about 30 minutes. With the students' written consent, Scholastic Assessment Test scores, Grade Point Averages (GPAs) and numerical grades in a course also are obtained. Associations between performance on the culture-fair tests, academic aptitude (Scholastic Assessment Test scores), and specific achievement (cumulative GPAs and objective test scores in college courses) are analyzed.

## Accomplishments

The contract was undertaken to discover if a valid, culture-fair test of intelligence based on the ability to process new information could be developed. Our initial results, reported to ARI on 8/18/05, were based on a sample of 421 students, drawn from a private university, two



colleges and a two-year community college, who participated during the initial 10-month period of the contract. We found that the tests of new learning, developed to that point, were culture-fair, reliable, and predictive of both academic achievement (numerical grades in class) and of a brief version of a standard test of scholastic aptitude (the Scholastic Assessment Test –Verbal [SAT-V]).

Continued testing since 8/05, using a revised version of the test of new learning, has involved a higher percentage of community college students (relative to those in the private university and colleges) than was possible during the initial contract period. A wider range of new learning, performance on the brief SAT-V, and academic achievement scores have allowed a more accurate determination of the role of information processing (new learning) and the role of the existing knowledge base (e.g. brief SAT-V scores) in the determination of academic achievement (grades). The results of the continued testing are now based on completed protocols from 596 students which, together with the sample of 421 students already noted, yields a final total of 1,017 participants. (The planned sample size was 900 participants). The latest results tell us, in accord with our previous studies, that tests of new learning are culture-fair. African-Americans perform as well as whites. Further they demonstrate again that tests of new learning and tests of existing knowledge each contribute independent variance to the prediction of class grades,  $R(2/593) = .47$ ,  $P < .0001$ , with Betas of  $.12$  ( $t = 2.4$ ,  $P < .017$ ) and  $.39$  ( $t = 8.3$ ,  $P < .0001$ ), for predictions from new learning and existing knowledge, respectively.

Two other findings are worthy of note. The first is that a subset of 18 of the 30 items tested on the tests of new learning proved to be particularly predictive of achievement,  $r(432) = .47$ ,  $P < .0001$ , and were solved equally well by members of different racial groups. These 18 items may constitute a test of new learning to be employed in future studies where the inclusion of other measures in a protocol may be done while keeping session length within the temporal bounds comfortable for participants.

The second notable finding is that a brief, 24-item version of the SAT-V that we created turns out to be as predictive of college grades as the standard SAT-V. We constructed the brief SAT-V because our community college participants are not required to take either the SAT or the ACT for admission to college and we wanted a measure of knowledge that would be common to both community college students and university students. We also wanted a measure that would be comparable to the standard SAT-V as to validity. A sub-sample of 371 students attending the private universities provided the data for a comparison of our brief SAT-V and the Standard SAT-V as to their comparative validity in predicting academic achievement. Measures of specific academic achievement (exam performance on objective tests) were obtained (with the students' permission) from the instructors of their courses. Cumulative Grade Point Averages representing at least two semesters of attendance were also obtained (with the students' permission) from the registrar at each institution.

Both the standard SAT-V and the brief SAT-V test were successful in predicting academic performance. Of most importance is the fact that the predictions from each test to academic performance were virtually identical. No significant difference was found between the SAT-V prediction of  $r = .30$  to class grade or the brief SAT-V test's prediction of  $r = .28$  to class grade,  $t(364) = 0.6$ ; similarly so for the predictions of each measure of aptitude to cumulative



GPA ( $r = .29$  and  $r = .26$ , respectively), with  $t(366) = 0.9$ . The results tell us that the scores derived from our brief version of the type of questions typically asked on the SAT-V are as predictive of academic performance in college as are scores derived from the SAT-V itself.

Currently, questions have been raised in a series of articles in the *New York Times* (e.g., Lewin, 2006) about the amount of time necessary to complete the SAT, which is estimated at 3 hours and 45 minutes (and longer for students with disabilities). Earlier reports in the *New York Times* (e.g., Arenson, 2005) revealed a sizable error rate in the current scoring process for the SAT. In the present ARI-sponsored study, we found that a very brief, easily scored version of the SAT-V would be as predictive of college grades as the standard SAT-V.

In summary, we find that there are at least two factors which determine success in a complex learning environment such as higher education: One is information processing (new learning) ability and the other is the extent of knowledge one has acquired to that point.

### **Contributions to Basic Science**

Jensen (1998) believes that the IQ score reflects what he calls the general factor (or  $g$ ) underlying intelligence. Differences in IQ scores are due to differences in  $g$ . According to Jensen, genetic factors play a primary role in determining  $g$ . Thus, Jensen (2000) believes that it may not be possible to come up with tasks that show no differences in test performance between Blacks and Whites and yet still predict academic performance. Fagan (2000) does not agree with Jensen, pointing out that the failure to develop tests of intelligence that can be fairly applied across racial groups stems from a theoretical bias to equate the IQ score with intelligence rather than with knowledge. If intelligence is defined as information processing and the IQ score as knowledge, the possibility of culture-fair tests of intelligence based on estimates of information processing arises. Fagan is not alone in such a conjecture. Williams (2000, p.17) notes that “Fagan’s ideas” (Fagan, 2000) of measuring thinking or information processing rather than accumulated knowledge are relevant to the debate on intelligence testing and affirmative action because...a true measure of processing efficiency (if it could be devised) would be fair to members of all racial and ethnic groups.” The chief theoretical implication of the results of the present study is that the assumption of equal opportunity for exposure to information made by theories of intelligence is false. When such an assumption is shown to be false, it becomes possible to develop culture-fair tests of intelligence that allow basic intellectual abilities to be recognized. Specifically, the inequality of educational achievement among races in our country has highlighted a need for culture-fair tests of intelligence. For example, Blacks do not do as well as Whites on IQ tests and other tests of knowledge such as the Scholastic Assessment Test. Basing admission to higher education on such test scores means that only a small percentage of Blacks are eligible for admission to colleges and universities. A culture-fair test of intelligence would allow basic abilities to be measured and would allow those with appropriate intellectual skills to pursue further schooling.

### **Potential Army/Military Applications**

Two of the guiding missions of ARI both historically and currently are to provide new technology to meet the personnel challenges of the Army in recruiting, selecting, and assigning



quality Soldiers and to provide scientific insight into leader development. The present research provides basic scientific data that may be applied by ARI to aid both in *Soldier selection, assignment, and performance* and in *leader development*. The results of the present contract may lead to applied research that would be meaningful to the Army in the development of new, applied behavioral technologies in order to identify individual differences in cognitive ability that may be used in the selection of Soldiers and in the identification of mature, effective leaders. In addition, the proposed research will provide data to aid such selection and identification to be culture-fair with regard to sex and race. In general, tests of information processing ability that are valid predictors of achievement in complex situations will have important military application. Such tests can aid in providing a valid means to evaluate volunteers and select candidates for advanced education or training in complex situations of the sort performed by Army personnel. Such tests can also be employed in further selection and training stages. In the field, such skills are also necessary to make quick and correct decisions based on rapidly incoming information. Skill in information processing is likely to be a key indicator of effective future Army leaders. Finally, using tests of information processing known to be culture-fair may provide an increase in the number of eligible recruits and an incentive to re-enlistment on the part of minorities.

*Specific transitions to applied research include:*

1. Selection, Classification, & Performance Metrics for the Future Force Soldier (STO IV. SP. 2002.1). Findings from our current research on the role of information processing ability can be applied to a *personnel selection and classification system geared [toward identifying Soldiers that are] self-directed and effective information processors and problem solvers, [a system that] might be incorporated into future enlisted selection and classification procedures [as well as being used as] outcome measures for future Soldier training and assessment*.
2. Performance Measures for 21st Century Soldier Assessment. Our findings may be applied toward the development of a *cost-effective...assessment system...for certifying a Soldier's qualification for job performance [and aid in the provision of] recommendations for an Army-wide system to certify the...qualifications of Soldiers for job performance*.
3. Future-Train: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs. The research focuses on how to measure cognitive skills that interact to influence performance in complex situations. Such aptitude may underlie the skills of future commanders and staff.
4. Leader Development, Accelerating Leader Development. The present research improves the assessment of cognitive skills, which will prove to be of importance to the selection and development of leaders.
5. Data on predictive validity relative to test length may be of benefit to the ARI applied program for Selection, Classification, & Performance Metrics for the Future Force Soldier (STO IV. SP. 2002.1).



## **Testing a Theory of the Determinants of Individual Job Performance for United States Army Junior Commissioned Officers**

**Contract #:** W74V8H-05-K-0005

**Institution:** Personnel Decisions Research  
Institutes (PDRI)

**Contract Dates:** 01/10/2005 to 09/30/2007

**PI:** Jeff W. Johnson

**Liaison:** Robert Kilcullen, SARU

**Problem(s)/Research Question(s)** – How do individual difference variables work to influence performance on specific performance dimensions relevant to junior commissioned officers in the U.S. Army?

**Technical Barrier(s)** – There is no well-established theory of the process by which individual-difference variables predict citizenship performance or adaptive performance, in either a military or a civilian context.

**Significance/Impact for Basic Research** – Support for this theory of performance would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria.

**Potential Transitions** – ARI has created various temperament scales thought to be related to adaptive performance and has empirically linked those measures to the mission performance of Special Forces (SF) Soldiers. ARI is now leveraging this measure to create a self-development feedback packet for SF Officers. The measures created in this basic research project are designed to predict performance at a more proximal level than the current temperament scales, so they could be used to revise or improve this self-development package or other Soldier self-development packages that are used outside of SF.

### **Overview**

Organizational citizenship performance and adaptive performance are increasingly important components of the Army junior commissioned officer job performance construct domain. Despite the importance of these constructs, there has been very little research studying them in a military setting. There is also no well-established theory of the process by which individual-difference variables predict citizenship performance or adaptive performance, in either a military or a civilian context. In this research, we are testing a theory of the process through which individual difference variables work to influence performance on specific citizenship and adaptive performance dimensions relevant to junior commissioned officers in the U. S. Army. Johnson (2003) proposed a theory of performance determinants that goes beyond earlier theories proposed by Campbell, McCloy, Oppler, and Sager (1993) and Motowidlo, Borman, and Schmit (1997), primarily by specifying an expanded conceptualization of motivation. Johnson broke the motivation component into specific motives (e.g., organizational commitment, job satisfaction), proactive cognitive processes (e.g., self-efficacy, goal commitment), and on-line cognitive processes (e.g., self-regulation). These variables, along with knowledge, skill, and habits, mediate the relationship between indirect performance determinants (e.g., cognitive ability, personality) and any kind of individual job performance construct.



Support for this theory would provide researchers and practitioners with a tool that can be used to identify the constructs through which individual difference variables work to influence performance on specific dimensions. This is especially important for identifying predictors of citizenship and adaptive performance. Such a tool would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria, and could be used to choose appropriate predictors for whatever criterion construct is of interest for a particular Army job. A rigorously developed and tested theory of the influence of individual differences on job performance would not only facilitate selection, classification, and training of junior commissioned Army officers, but would also add significantly to the evolving understanding of job performance.

## **Research Approach**

In order to test this theory, we assembled and developed a battery of instruments that are construct-valid measures of each component of the theory. All measures created for this project are based on input from ROTC cadets. To measure task, citizenship, and adaptive performance, we created a multisource performance rating instrument measuring performance on five different dimensions. We created a past behavior record to measure skill and a situational judgment test to measure knowledge, both of which are relevant to five performance dimensions. We also created (a) a unique self-report measure of work habits; (b) a motives scale assessing attitudes, values, and preferences that predict performance; and (c) a motivation scale measuring self-efficacy, expectancy, goal content, and goal commitment. We also created a self-regulation scale to measure the extent to which respondents were able to focus on performing the behaviors they indicated they intended to perform. We also assembled a battery of existing instruments to measure cognitive ability, personality, experience, and action control.

The predictor battery was administered to 155 ROTC cadets in the Fall of 2006. Criterion administration took place during March and April of 2007, allowing us to assess the extent to which cadets performed the behaviors they intended to perform. The self-regulation scale was administered four times during this period, allowing us to track how well each cadet was able to maintain focus on performing these behaviors. Each cadet was rated by approximately four peers. These data will be analyzed using structural equation modeling to test the Johnson (2003) theory, as well as several ancillary hypotheses.

## **Accomplishments**

Accomplishments to date have been (a) the determination of the performance dimensions to be studied in this project, (b) the development of the instruments designed to measure each component of the theory, (c) the recruitment of cadets and midshipmen in ROTC programs to participate in the research, and (d) data collection.

The performance dimensions were identified by presenting a list of specific performance dimensions relevant to task, citizenship, and adaptive performance to a group of nine ROTC cadets. Through group discussion, we identified one task performance dimension, three citizenship performance dimensions, and one adaptive performance dimension that (a) are especially relevant to ROTC cadet performance, (b) are observable by other cadets, and (c)



display variation in the level of performance among cadets. The performance dimensions are (a) decision making/problem solving, (b) maintaining good working relationships, (c) organizational commitment, (d) showing initiative, and (e) adapting to changing or uncertain situations.

We developed the following instruments:

- Performance measurement instrument – This instrument consists of 37 items measuring cadet performance on the five performance dimensions. Each item is a behavioral statement that represents effective performance on one of the performance dimensions. Raters will use a 5-point rating scale to rate the extent to which the statement describes the individual being rated.
- Experience Inventory – This instrument consists of the same items that are on the performance measurement instrument, and respondents indicate the degree of experience they have performing each behavior.
- Past Behavior Record – This instrument measures skill relevant to the five performance dimensions. The individual describes a situation he or she has experienced that elicited behavior relevant to each of the performance dimensions and the behavior he or she exhibited. Trained raters used standardized rating scales to evaluate the level of skill that each behavior represents. Two types of rating scales were developed to determine which yields scores that better predict performance.
- Situational Judgment Test – This instrument measures knowledge relevant to the performance dimensions. Each item consists of a situation and a set of response options that vary in their effectiveness. The respondent uses a 7-point scale to rate the level of effectiveness each response represents, as well as choosing the most- to least-effective response.
- Military Motives Scale – This instrument measures values, interests, preferences, and attitudes that are expected to predict behavior relevant to the five performance dimensions. This instrument includes measures of job satisfaction; military values; affective and continuance commitment; the citizenship motives of organizational concern, prosocial values, and impression management; and interest in being in situations that require behavior relevant to the performance dimensions.
- Work Habits Scale – This instrument measures the extent to which behaviors relevant to each of the performance dimensions are consistent with the respondent's habitual way of doing things.
- Proactive Cognitions Scale – This instrument includes questions about expectations, self-efficacy, and intentions to perform behaviors relevant to the performance dimensions.
- Self-Regulation Inventory – This instrument measures the extent to which participants were able to maintain their intentions to behave in a certain way when presented with the opportunity over the previous four weeks.



We recruited participants from Army, Navy, and Air Force ROTC programs at six different universities. We also obtained IRB approval to conduct the research at each university. The universities were:

- University of Minnesota (Army, Navy, Air Force)
- University of South Florida (Army)
- University of North Carolina-Charlotte (Air Force)
- Colorado State University (Army, Air Force)
- Michigan State University (Air Force)
- Purdue University (Army, Air Force)

We administered one set of predictor instruments in in-person testing sessions, and the remainder were administered online. We obtained complete predictor data from 155 respondents. Those respondents also completed four Self-Regulation Inventories approximately once a month following predictor administration. Criterion administration began in mid-March and is ongoing.

### **Contributions to Basic Science**

This project will advance our understanding of job performance prediction by providing evidence in support of a theory of the process by which individual-difference variables predict specific dimensions of performance. Many theories of the relationship between individual differences and job performance have been proposed, but there is very little empirical support for any of them. This is especially true for less-studied aspects of performance such as citizenship performance and adaptive performance, which are the primary focus of this research. An established model of the process by which individual differences in predictor variables lead to individual differences in specific dimensions of performance can be used to guide research linking specific predictors to specific performance dimensions by helping to identify theoretically relevant predictors for different criteria. In the proposed model, the construct of motivation is expanded to highlight how different predictors influence different components. Self-regulation is the primary component that previous models were missing. This construct is very important because it (a) is strongly related to personality; (b) helps explain how people with similar knowledge, ability, goals, and desire to perform differ in their level of performance; and (c) helps explain how people overcome conflicting habits to perform in accordance with their goals.

This project also will yield several potentially useful products. We created a multisource performance rating instrument to measure task, citizenship, and adaptive performance. These performance components are important aspects of the Army junior commissioned officer performance construct domain. We created a situational judgment test (SJT) to assess knowledge relevant to the performance dimensions chosen for study. The SJT presents the individual with a situation and a set of response options varying in their effectiveness. We developed a past behavior record to measure skill relevant to the targeted performance dimensions. Using a highly structured format to minimize the possible confounding effect of writing ability, cadets described a recent situation they experienced that elicited behavior relevant to the performance dimension of interest and the behavior they exhibited. Trained raters used standardized rating scales to evaluate the level of skill that behavior represents. By allowing respondents to describe their best



example of behavior relevant to a performance dimension, we can assess the extent to which the person is able to exhibit the behavior irrespective of the extent to which they typically exhibit the behavior. To measure the components of motivation described in Johnson's (2003) model, we created (a) a unique self-report measure of work habits; (b) a motives scale assessing attitudes, values, and preferences that predict performance; (c) a cognitive processes motivation scale measuring self-efficacy, expectancy, goal content, and goal commitment; and (d) a self-report measure of self-regulation with respect to targeted behaviors.

### **Potential Army/Military Applications**

Support for the performance model will provide the Army with a tool that can be used to identify the constructs through which individual difference variables work to influence performance on specific dimensions. This is especially important for citizenship and adaptive performance, which are important components of Army officer jobs but have received little research attention in a military or civilian context. Such a tool would contribute to a better understanding of the relationships between predictors, mediators, and job performance criteria. For the Army, this tool would probably have its best application in identifying training and/or development needs. Given a criterion construct on which an individual's performance is in need of improvement, this model can help to identify the determinants of performance on that construct. For example, an individual possessing adequate skill and knowledge may determine that he or she must learn new self-regulatory strategies to overcome counterproductive task-related habits.

This project will yield several products that may be very useful to the Army. First, the various motivation-related instruments we developed/assembled and will validate against criteria of importance to the Army should prove to be quite useful as self-development tools. Completing these instruments can help Soldiers and/or officers learn about their own attitudes, values, goal commitment, self-efficacy, self-regulatory skills, and habits relevant to five critical performance dimensions.

Second, the Past Behavior Record Form may prove to be useful for training. In particular, the evaluation guide used to score this instrument will provide useful information regarding where various skill-relevant behaviors fall on various performance continua. Moreover, the principles induced during the process of calibrating the performance-relevant skills to different points on these anchored rating scales will make useful learning points in training programs. The situational judgment test will also be a useful self-paced training tool. Individuals are presented with realistic situations and choose from a variety of alternative response options. Explanations of the strengths and weaknesses of each response can be developed to help the trainee understand the level of effectiveness of the chosen option and the most effective option.

Finally, the performance rating form may have applied value for performance appraisal, training needs analysis, or criteria for future validation studies. In addition, it would make a useful feedback and development tool. The performance rating form is a multi-source rating instrument. As such, it will not only provide a profile of strengths and weaknesses, it will provide information about discrepancies between how an individual is seen from different perspectives (i.e., subordinates, peers, superiors). It would be extremely useful, for example, for

a junior officer to become aware of differences between his or her self-perceived performance and the perceptions of his or her performance held by subordinates.

### **Future Plans**

By the end of Fiscal 2007, we will conduct the following activities:

- Complete criterion data collection.
- Analyze data. Some of the questions to be addressed with these data are:
  - Is adaptive performance distinct from task and citizenship performance?
  - Which SJT scoring method yields the highest validity when predicting performance?
  - Does this SJT measure distinct constructs?
  - Is each instrument developed or assembled for this project a valid predictor of the dimension(s) of performance it is intended to predict?
  - Which type of rating scale developed for the Past Behavior Record yields scores that better predict performance?
  - Do the data fit the Johnson (2003) model, in terms of hypothesized mediating variables and hypothesized moderating variables?



## **Goal-Driven Perception and Cognition in Complex Social Environments**

**Contract #:** W74V8H-05-K-0003

**Institution:** Arizona State University

**Contract Dates:** 01/01/2005 to 12/31/2007

**PI:** Douglas T. Kenrick

**Co-PI:** Steven L. Neuberg

**Problem(s)/Research Question(s)** – How do common social goals relevant to military situations (e.g., self-protection, other-protection, retribution) influence early-stage cognitive processing of complex social environments? To which person in a crowd will we pay attention, for example, and how will we interpret his or her facial expression? How do these goal-driven processes shape important down-stream behavioral decisions (e.g., to shoot vs. not shoot a possible enemy combatant)?

**Technical Barrier(s)** – Until recently, little effort has been made to link theory about fundamental social goals and their associated emotions to theory about how people process information during the first seconds of an initial encounter.

**Significance/Impact for Basic Research** – This research will help conceptually integrate two important, but disconnected, research literatures while also providing empirical data that tests hypotheses about goal influences on cognitive processing of complex social environments.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed for identifying those individuals most susceptible or resistant to particular goal-related information processing biases, identifying those individuals most in need of training to overcome such biases, and designing training programs to mitigate such biases. We suggest that our research may be most directly relevant to the following applied programs:

- The Army's Science and Technology Objective: Soldier (STO IV.SP.2002.01)—Selection Classification, and Performance Metrics for the Future Force Soldier;;
- The Army's Science and Technology Objective: Training (STO IV.SP.2003.06)—Objective Force Warrior Training;
- The Army's Science and Technology Objective: Training (extension of Future Force Warrior Training)—Maximizing Small Unit Performance;
- The Army's Science and Technology Objective: Training—Ground Systems Team Training;
- The Army's Science and Technology Objective: Training (STO IV.SP.2003.06)—VICTOR: Virtual Individual and Collective Training for Future Warriors; and
- The Army's Science and Technology Objective: Leadership Development—Assessing and Developing Leaders for Special Operations Units.

### **Overview**

Soldiers often encounter extremely complex social situations in which they must rapidly make difficult, life-or-death decisions. However, human cognitive capacities are limited in ways that make it impossible to attend equally to every individual or even to all characteristics of any given individual encountered in such a setting (imagine a crowded market in a large city).



Instead, people must focus their attentional and information processing resources on a small subset of individuals and characteristics. The selective direction of cognitive processing often occurs automatically, without conscious intent, and is highly susceptible to biases that can potentially lead to serious errors (e.g., failing to process clues of an impending fatal ambush or mistaking an innocent civilian for an armed insurgent). Furthermore, a person's current motivational state may change the ways in which that person allocates attention and other limited cognitive resources. The aim of the proposed research is to assess how common social goals—self-protection, other-protection, and retribution—shape attention and information processing in complex social environments and thereby influence important down-stream behavioral decisions.

## **Research Approach**

We proposed to run 10 laboratory experiments designed to test hypotheses derived from our conceptual framework. Each experiment has employed established research paradigms and methodologies used in social psychology and cognitive science designed to tap different levels of processing—from visual attention (measured via eye-tracking) and interpretation through memory and decision-making (e.g., tasks requiring rapid friend/enemy distinctions and shoot/don't-shoot decisions). In addition, each study has included manipulations of participants' goals (self-protection, other-protection, and/or retribution). Besides experimental manipulations, we have assessed chronic individual differences in these goals. Participants are confronted with complex social scenes in which target individuals differ in their sex, age (combatant age or not), group membership (ingroup, outgroup, or outgroup ally), facial expression (angry or not), and/or possession of a weapon. We have examined how these different goals alter visual attention to, encoding of, memory for, and/or behavioral decisions about the different individuals in the scenes.

## **Accomplishments**

Thus far, we have completed data collection for all 10 proposed experiments, and are currently completing data analysis, integrating findings across studies, and beginning to prepare research papers describing the interesting results. To overview, preliminary results indicate distinctive patterns of cognitive bias in the processing of adult Arab males, as well as several interesting interactions between cognitive processing and participants' motivational states. Participants in control conditions are generally not good at distinguishing adult Arab males they have seen from those they have not seen. Furthermore, adult Arab males are most likely to be labeled as enemies (even when they are not), and to have anger attributed to them (even when they are displaying neutral facial expressions). When any one of various forms of threat are aroused, people become better at distinguishing among individual Arab males. Men who are experiencing revenge motivation, although also more attentive to individual Arab males, are also quicker to decide to shoot those individuals in a rapid decision-making task.

Two of our studies (Experiments 1 and 2) were designed to assess how social motivations (i.e., feeling self-protective, other-protective, or vengeful) would influence visual attention as measured via eye-tracker technology. In those studies, we recorded how participants visually scanned a group of people (including men and women, as well as boys and girls, who were Arab or European, and wearing angry or neutral facial expressions). We later asked participants to



identify particular faces that had been in those arrays, and the test included an equal number of people in each category that they had not seen before. This combination of tasks allows us to examine processing efficiency, or “bang for the attentional buck,” by calculating the relationship between amount of time spent looking at a particular type of face and later memory for faces in that category. One interesting finding from that research is that women concerned with self-protection become increasingly efficient at processing Arab males.

Two of the studies (Experiments 3 and 4 from the proposal) were designed to assess how the same social motivations affect rapid categorization of other people as enemies or allies. Each participant viewed 128 photos varying by gender, group (European-American vs. apparently Arab), age (mid-20s vs. elementary-age children), and facial expression (angry vs. neutral). Half the targets were randomly labeled with an ingroup insignia, and the others were randomly labeled with the enemy insignia. Data analysis for Experiment 3 suggests that participants were generally biased toward identifying Arabs as enemies and Europeans as friends; they are also biased toward identifying females as friends. When concerned with self-protection, the bias to identify Arabs as enemies increased. Moreover, participants were slower to react to angry Arab faces, and were especially biased to call them enemies even when they were not; this was particularly the case for participants who possessed implicit prejudices against Arabs to begin with. In contrast, participants were quick to react to neutral European faces, and were especially biased to call them friends even when they were not; this was particularly the case for participants who are dispositionally inclined to see the world as a dangerous place. Revenge motivations also seem to create a bias to identify ingroup members as friends (even when they were not); this bias was pronounced among participants who dispositionally view the world as a dangerous place. A manuscript based on these results is being prepared.

Two studies (Experiments 5 and 6 from the proposal) were designed to assess how social motivations affect attributions of anger to neutral faces of different groups. The most interesting finding from this research is that attributions of anger are higher for Arabs, for men, and for adults. As a result, judges generally tend to attribute relatively high levels of anger to adult Arab males (even when they are in fact displaying neutral facial expressions).

Two of the proposed studies (Experiments 7 and 8 from the proposal) were designed to assess how the presence of individuals relevant to some motives might interfere with the cognitive processing of other individuals relevant to other goals. In these studies, participants view pairs of photographs that contain either an adult Arab male, an adult European-origin female, or a crying child, to examine (1) whether and in what way these stimuli interfere with the processing of other faces presented alongside them, and (2) whether the nature of this interference differs depending on the perceiver’s active and chronic goals. Whereas participants had an especially difficult time accurately differentiating Arab targets from one another in memory under baseline conditions, each of the threat manipulations improved this performance. Moreover, each of the threat motivations created a tendency for Arab male targets to “trump” the recognition of white female targets (i.e., to make it more difficult for participants to differentiate in memory European-origin females from one another); in the retribution condition, Arab male targets also “trumped” recognition memory for (the normally attention-grabbing) crying children. For our participants, the presence of Arab males appeared to “steal” processing away from other target individuals in the social context.



Two of the studies (Experiments 9 and 10 from the proposal) were designed to assess how the three motivations affect rapid categorization of other people as threats or non-threats and the decision to shoot those carrying a weapon. Each participant viewed photos varying by gender, group (European-American vs. apparently Arab), and facial expression (angry vs. neutral). Half the targets were holding a weapon, and the other half were holding a wallet or a cell phone. The participant's task was to shoot only armed targets, regardless of gender, ethnicity, or emotion. When motivated by retribution, participants were especially likely to not shoot *unarmed* Europeans and to shoot *armed* Arabs, but they also exhibited a bias to shoot unarmed Arabs.

### **Contributions to Basic Research**

This research promises to make several important contributions: (1) It theoretically links research literatures addressing how fundamental human goals affect information processing with ecologically inspired theories of motivation and cognition; (2) The particular findings are contributing to a theoretical framework for understanding how goals related to self-protection, other-protection, and retribution shape early-stage attention and interpretation of complex, information-rich social environments, and thereby influence subsequent behavioral decision making; (3) We have been able to provide rigorous empirical tests of the hypotheses derived from this framework; and (4) The findings have suggested a number of interesting new questions worth pursuing. Thus, this research should help expand upon the field's understanding of motivated social perception and cognition.

### **Potential Army/Military Applications**

Several of these findings seem highly relevant to understanding how a Soldier's perceptual, cognitive, and decision making processes may depend, for example, on whether he or she is primarily concerned in the moment with self-protection, protection of a friend or comrade, retribution for an attack on one's country or the death a comrade, or the safety and well-being of innocents in the field. Although not all data are yet analyzed, initial results do have direct relevance to Soldiers making judgments in conflict situations. The findings that judges are generally not good at distinguishing Arab males from one another, are disposed to label those individuals as angry and as enemies even when they are not, and are quicker to make a decision to shoot those individuals are of direct relevance to Soldiers involved in Middle Eastern conflicts, who must in fact distinguish between friendly and hostile Arabs. Given that combatants may include both men and women, it is also of interest that revenge motivation increased the proclivity of men to shoot Arab males, whereas self-protection increased the proclivity of women to process Arab males efficiently and accurately.

### **Future Plans**

Several preliminary findings from this program have been presented at national conferences, and are currently being developed into manuscripts for publication. We also are conducting additional analyses of the sometimes complex data sets, such as linking eye-tracking and memory findings, as well as exploring individual differences. We expect these more thorough analyses to uncover additional interesting patterns. Several potential follow-up studies



are suggested by the current patterns of findings. Possible lines of follow-up research involve the questions: (1) Do there exist individual differences in the patterns of these cognitive biases, such that individuals may be characterized by “syndromes” of biases they exhibit, perhaps related to chronic sensitivities to fundamental motives, and that may influence how these individuals process information in complex social environments? Such a question would seem to have important implications for how one might identify those military personnel particularly susceptible to particular decision errors (or high quality decisions) in the field. One approach to exploring this would be to administer batteries of all our different measures and tasks to the same subjects across multiple measurement sessions, thereby enabling us to identify social-cognitive processing “types.” (2) Given these demonstrable biases, and their particular relationships with motivational states, how would one train these biases away? Would the training approach differ depending on the particular patterns (syndromes) of bias individuals exhibited? (3) The types of cognitive biases we’ve demonstrated here also will likely be exhibited by those in contact with U.S. Soldiers, such as civilians and enemy combatants in foreign lands. Given what we’re learning about how the biases are elicited, and their motivational underpinnings, what strategies might be useful to lessen the likelihood or reduce the impact they have on the perceptions and treatment of these Soldiers?

## An Integration of Motivation Theories

**Contract #:** DASW01-04-K-0001

**Institution:** The Hebrew University of Jerusalem

**Contract Dates:** 12/12/2003 to 12/11/2007

**PI:** Avraham N. Kluger

**Liaisons:** Trueman Tremble, SARU  
Robert Solick, LDRU

**Problem(s)/Research Question(s)** – What are the implications of win-win approaches to between-person negotiations for inner person conflict resolution?

**Technical Barrier(s)** – Studying real conflicts without upsetting participants and helping them in return for their participation.

**Significance/Impact for Basic Research** – Extending our tool box, which we started to develop in 2005 and reported in 2006 (*Feedforward*), to provide tools for increasing both well-being and productivity of employees, coupled with testable theoretical rationale.

**Potential Transitions** – Knowledge gained during our 2006 work may be usefully employed in:

- Performance Appraisal (*Feedforward* reported last year);
- Various Army training programs; and
- LEADERSHIP: Developing leaders in a changing Army (WP 103).

### Overview

The current work has diversified into multiple inter-related projects. Due to space limitations, however, the report below focuses on the key development during 2006—The Negotiation Self (with Ph.D. student Dina Nir).

Negotiation is a fact of life. We negotiate every day of our lives and in every possible kind of situation, whether we are trying to buy a house, build team consensus, decide where to go for lunch, or convince the kids to go to bed. These negotiations call for the unfolding of complex communication processes between two or more people with the aim of reaching an agreement. Recent developments in understanding the complex concept of the *self* suggest that we do not only negotiate with others, but first and foremost we negotiate within ourselves (Hermans, 1996).

The self, according to Hermans (1996) is organized as a dialogical interchange between mutually influencing selves, or I-positions in an imaginary landscape of the mind. These dialogical interchanges allow communications between often opposing and conflicting I-positions to be internally voiced so that a decision can be reached. In the current work, internal dialogical interchanges are viewed as intra-personal negotiations that guide and shape one's choice and behavior; hence the term *negotiation self* is introduced. According to this stance, negotiations within the self correspond to inter-personal negotiation processes and strategies, and therefore can be explained, analyzed and ultimately transformed through applying *collaborative principles*, developed in the field of negotiation.



In negotiations, reaching integrative solutions, as opposed to reaching distributive outcomes or compromises, can be facilitated by using *principled negotiation*, a term given to the interest-based approach to negotiation first formulated by Fisher & Ury (1981). The core of this approach, which is considered the “big bang theory” in negotiation (Thompson & Leonardelli, 2004), is that understanding one’s deep-seated needs and interests, rather than one’s positions, is the key to creating innovative and creative solutions, and reaching integrative agreements. Interests are distinct from positions in that interests are the underlying concerns, needs, desires, or fears that motivate a negotiator to take a particular position (Fisher, Ury, & Patton, 1991). Positions, on the other hand, are the specific and tangible items people say they want. When analyzing the interest, it is also important to distinguish between visible and hidden interests. Visible interests are those interests that people are willing to talk about and discuss openly. In contrast, hidden interests are often personal interests that people tend to avoid discussing, such as increasing status, power, recognition and esteem. However, more often than not, these hidden interests have a decisive effect on organizational decisions and outcomes.

Armed with these insights regarding interpersonal negotiations, four hypotheses are put forward: First, as in inter-personal negotiations, negotiations within the self lead to either integrative (win-win), or distributive (win-lose) outcomes. Second, each of these outcomes (win-win or win-lose) leaves its unique affective trace. Third, people frequently use either an integrative or distributive *negotiation schema* that manifests itself in both intra-personal and inter-personal negotiations. Finally, inner negotiations can be transformed from distributive to integrative processes with an interest-based approach to negotiations. An interest-based approach is expected to promote innovative solutions that satisfy conflicting needs and interests within the self. Two empirical studies were already run to address and validate this theoretical development. In the first study, a convenience sample of 99 respondents answered an open-ended survey regarding one key conflict from their past. This study (see below) allowed us to establish that (a) inner conflicts can be reliably classified on a scale ranging from win-lose to win-win, just like between-person conflicts, and (b) emotions reflect the quality of the decision. In a second study (data are still being collected), respondents reported an inner conflict and their current solution for it. They were given instruction regard integrative negotiation, asked to offer a new inner conflict solution, asked to discuss their solution with a supportive but challenging partner, and to report their new solution again. Initial results suggest that this training enhanced the degree to which one’s conflict resolution reached a win-win solution for his or her multiple inner voices.

## Research Approach

In addition to the theoretical development that was based on multiple meetings with Ph.D. students, and clinical observations gained while coaching multiple managers with these ideas, here I report the approach of the first completed study. A convenience sample of 99 respondents answered a questionnaire regarding one’s salient but solved conflict. Next respondents were instructed to list all the voices they considered in making the decision, share their actual decision, and report their emotions at the time of the decision. A scale of emotion ratio was calculated by dividing the mean of the positive emotions items by the mean of the negative emotion items (a score larger than 1 means largely positive emotions). The conflict

scripts were read by two judges who independently rated them on a -5 (win-lose) to +5 (win-win) scale.

### Accomplishments

First, an inter-rater reliability (ICC2) of the two judges was .80, indicating that negotiation outcomes within the self can be reliably identified on a continuum ranging from win-lose to win-win.

Second, the correlation between type of outcome (win-win or win-lose), and the ratio of positive over negative emotions was high:  $r = .51$ . However, inspecting the scatter plot of these data (Figure 1) is even more instructive.

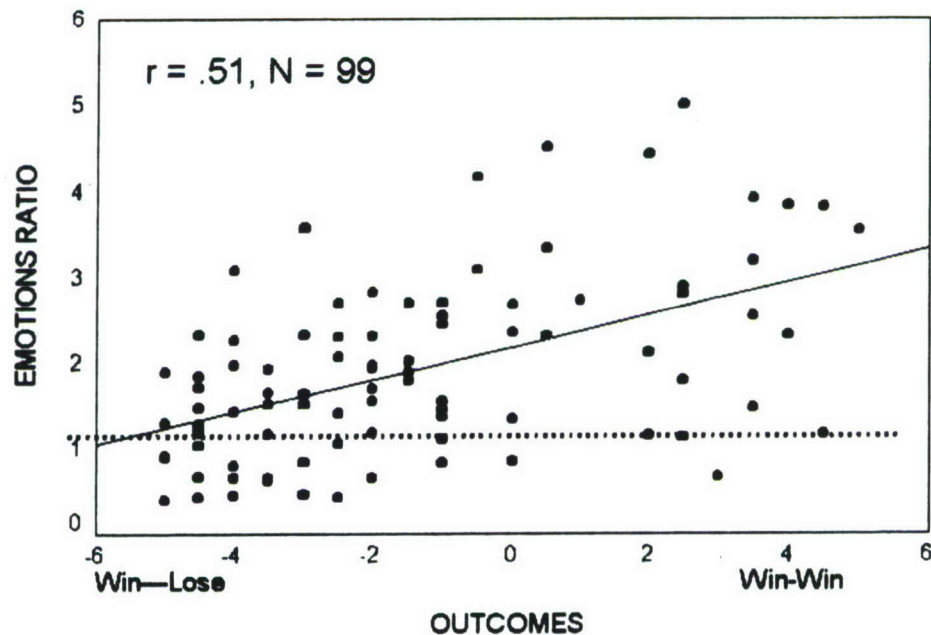


Figure 1. Emotions and internal negotiation outcomes.

The blue dots represent individuals' scores both on the judges' scale of outcome (the X axis) and their own self report regarding their emotions (the Y axis). The solid line represents the prediction of one's emotions on the basis of the judges' rating of one's outcomes (the regression line). The dotted line marks emotion ratio of 1. Scores higher than 1 indicate largely positive emotions. Two features of this scatter plot are striking. First, the majority of respondents (over 2/3) reported reaching win-lose outcomes. Second, only one person reported largely negative emotions and was rated to have a win-win outcome, in contrast to 14 respondents who reported largely negative emotions and were rated to have a win-lose outcome (compare the number of dots below the dotted line to the right of 0 on the X axis with number of dots to the left of the 0).



This suggests that emotions reflect the quality of the negotiation outcomes within the self: The more win-win one's outcome, the better one feels. This may appear trivial, but suggests the following intervention whenever a person reaches a decision, ask "How do you feel now?" If you do not feel well, you may want to review your decision and search for a better solution.

### **Contributions to Basic Research**

First, our findings indicate that the literature on interpersonal negotiations can be integrated with the literature on the multi-voiced self to expand personnel and leadership development. Specifically, tools used to separate interests from position can be relevant for person development. Second, our findings hint at the possibility that most people reach sub-optimal decisions, due to an inner schema of win-lose. This opens the door for multiple theoretical questions and practical interventions. For example, is the tendency to reach win-win solutions chronic? If yes, it may have implications for personnel selection. Finally, if corroborated, our findings suggest a way of understanding emotions as a reflection of the quality of the inner-theatre. Again, this has both theoretical and applied implications.

### **Potential Army/Military Applications**

We believe that training in inner-conflict resolutions can be applied in various military settings. At this level of development of our negotiational self tools, we believe it can be tried in:

- Designing training
- Leadership development

### **Future Plans**

The plan for 2007—the last year of this contract—is to complete the current and two other key projects. First, it is planned to test the effectiveness of training people to think win-win while solving inner conflicts. We also hope to test whether inner conflict resolution style influences between-people negotiation style.

Second, the feedforward tool reported in 2006 is now under empirical testing. The plan is to demonstrate that the feedforward interview yields more positive emotions, more positive social emotions, better insights, and better performance in comparison to feedback and controls.

Third, another project to be fully reported next year is geared towards integrating goal-orientation theory with value theory. Its essence is showing that current thinking about achievement situations can be augmented by considering amity goals. It is planned to complete (a) empirical demonstration that amity goals are relevant and influential in achievement situations, and (b) experiments demonstrating that coupling amity goals with mastery goals (as opposed to contest goals with performance goals) insulate people from the damaging effects of negative feedback.

## **Comprehension and Memory of Spatial and Temporal Event Components**

**Contract #:** DASW01-02-K-0003

**Institution:** University of Notre Dame

**Contract Dates:** 05/01/2002 to 04/30/2006

**PI:** Gabriel A. Radvansky

**Liaison:** Tonia Heffner

**Problem(s)/Research Question(s)** – How do people detect and process changes in space and time for on-going situations? That is, how is effective cognition influenced by the environmental structure of dynamic events as they are happening?

**Technical Barrier(s)** – Models and theories of event comprehension and memory are only currently emerging and virtual reality technologies are also developing.

**Significance/Impact for Basic Research** – Understanding how people monitor and update changes in situations will allow for more developed models of how people comprehend and remember information about unfolding events in the world.

**Potential Transitions** – Knowledge gained in this research may be usefully employed in:

- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211);
- MEASURE DIGITAL: Defining and Measuring Digital Skill Proficiency (WP 234);
- Future Force Warrior Training (WP 215); and
- VICTOR: Virtual Individual and Collective Training for Future Warriors (WP 233).

### **Overview**

To perform successfully, people need to deal with changes that occur during events. They need to identify when changes have occurred, and update their understanding of the event accordingly.

There are many components of event memory and comprehension (Zwaan & Radvansky, 1998), including space, time, entities, causality, and intentions. Recent work by Radvansky and Copeland (2000; 2001; 2004a 2004b; Radvansky, Copeland, Berish & Dijkstra, 2003; Radvansky, Copeland & Zwaan, 2003; Radvansky, Zwaan, Curiel & Copeland, 2001) has shown that the ability to track these changes is unrelated to working memory span (i.e., the amount of information that a person can hold in mind at one time). Instead, it appears to involve mental processes that are specific to situations and events.

- The focus of this project is on changes in event space and time when people need to know whether elements from the previous situation are still relevant. For example, for learning about a traveler going from New York to London, a person needs to mentally track that the traveler brought a computer disk with classified information with her, and left behind a book of contacts. Although space and time are basic elements of events, people do not always actively monitor and update their understanding (Zwaan & von Oostendorp, 1993; Zwaan, Radvansky, Hilliard, & Curiel, 1998).



- More recently, we have extended our efforts beyond language comprehension to interactive experiences in virtual reality. We assess how spatial updating influences the actual experiences with events. This line of work addresses two issues.
  - First, when there are changes in spatial location, information about entities carried over to the new location should remain available in memory, whereas information about entities that are left behind should be less available (e.g., Glenberg, Meyer, & Lindem, 1987).
  - The second is that as a person moves through space, the further things are from the current location, the less available that information should be (Morrow, Greenspan & Bower, 1987). By looking at how changes in space during an on-going event are disrupting thinking, we can target those aspects of the situation that are giving people the most trouble, allowing training and technology to target these deficits.

## **Research Approach**

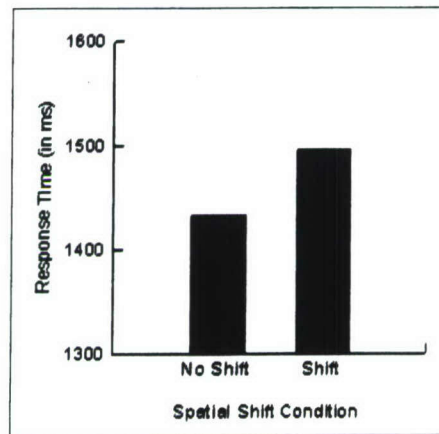
In some of our experiments, people read narratives, one sentence at a time, and reading times were recorded. Reading times provide an index of difficulty. When an event shift occurs, people exert effort to update their understanding of the situation, and reading times increase. Thus, a noticed change in space or time would show a slow-down in reading times. In addition, reading was interrupted with probe words. These probe words assessed the progress of a person mentally updating their event understanding (i.e., WHAT they were thinking about). The task was to indicate whether these words referred to the narrative. People would respond faster when they referred to elements that were part their thinking about the current situation.

In our virtual reality work, people navigated through environments with some goal, such as moving objects from room to room. We looked at the availability of information about an object as a function of whether it was being carried, or had just been put down. This assessment was done by stopping the movement and presenting people memory probes (object names). The task was to indicate whether the object was one that was currently being carried, was just set down, or some other object. In other cases, people memorized the layout of a building prior to navigation. At different points, they made location judgments about various objects. This was done to assess the influence of both prior knowledge and spatial distance on event knowledge.

## **Accomplishments**

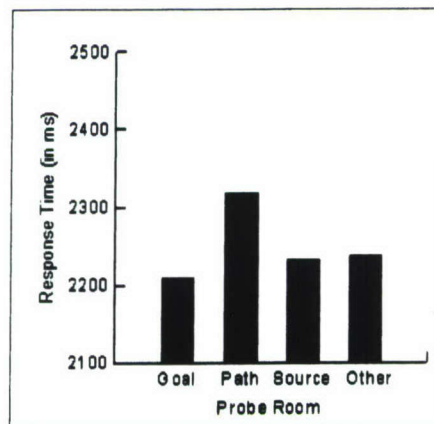
*Updating.* There were a number of key findings from this research. First, people are successful at updating their understanding of an event when there is a change in space or time. Second, when there is a shift to a new spatial location, people are more facile at making this transition, whereas shifts in time require more effort. Third, the ease with which spatial shifts are made is supported by the finding that people are able to remove information about newly irrelevant entities from the prior situation from their current stream of thought. Fourth, the difficulty people have with a shift to a new time frame is supported by a decreased ability to remove information about newly irrelevant objects.

*Virtual Reality (VR).* In our virtual reality studies assessing spatial updating, there are two aspects of event interaction that impacts the ability to monitor the situation. First, knowledge of things that people are carrying is more available than things they have just set down. More importantly, we have found that when people move from one location (room) to another, thinking about the on-going event is disrupted. Most prominently, knowledge of what objects a person is carrying is disrupted. This is shown in the Figure 1 in which the speed that people retrieve information is slowed after there is a spatial shift.



*Figure 1.* Response times (in ms) to object name probes as a function of whether people had just made a spatial shift.

Our VR studies have also found that when people move from one room to the next in a well-known area, information about the room just left drops in availability as people mentally work to understand the new situation. Figure 2 shows the speed to identify information about objects when a person has moved from one room (*Source*) through a second (*Path*) and ending up in a final (*Goal*) room. The figure also shows the availability of objects from *Other* rooms. People are slowest at retrieving information about objects from a room they passed through, suggesting that shifts in location disrupt the ability to retrieve recent event information.



*Figure 2.* Response times to memory probes (object name pairs) as a function of distance from the subjects' current position in the virtual environment.



## **Contributions to Basic Research**

This project provides a more advanced understanding of how people monitor event changes in the world. This research follows several recent developments in theories of mental models (mental simulations that we create) and theories of embodied cognition (how our thinking is influenced by how we interact with the world). Our analyses will allow for a clearer understanding of how people comprehend and remember changes in events. From these data, we hope to develop a means of identifying when people are having trouble updating event information, and provide a more targeted means of dealing with those difficulties.

## **Potential Army/Military Applications**

The potential applications of this research for the Army are in the areas of training and system interfaces. In the area of training, this research will provide insight into the specific difficulties people have updating their understanding of events. Knowing in what ways people have trouble tracking changes in space and time will allow for the development of procedures that would directly target such difficulties. In addition, because the modern Soldier needs to interact with sophisticated technologies that involve tracking various entities through time and space (whether they be enemy forces, one's own supplies, friendly forces, noncombatants, etc.), knowing the capabilities and limits of human event comprehension and memory will help in the design of these systems. Spatial and temporal information that is readily tracked by people would need either minimal or no feedback from the system. However, those aspects of spatial and temporal processing that are more difficult would be a higher priority for that system, in terms of augmenting the Soldier's current capabilities.

## **Final Summary**

The aim of this research was to better understand the influences of the structure of events in the world on the ability of people to comprehend, remember, and generally process information in ongoing situations. This line of study was pursued because our ability to manage knowledge, and hence perform, in the world may be directly influenced by how we interact with the world, and not simply be the result of our intellectual abilities and histories.

To explore this sort of event-based cognition, we assessed performance when people were either reading texts or navigating in virtual environments. When people read texts, we assessed performance as a function of whether a shift to a new spatial or temporal framework had occurred in the events being described. We measured the effect of that shift on performance, as well as the ability of people to maintain currently relevant information, and to remove newly irrelevant information. What was found was that while changes in spatial location are more easily processed, people have difficulty processing information about temporal shifts, both in terms of the processing of the change in the time frame, as well as the coordination of accompanying knowledge that would be affected by the temporal shift.

When people navigated through virtual environments, in one series of studies we had people move objects about and tested the availability of knowledge about those objects. Of



critical importance was whether people had moved through a doorway or not. What was observed was that performance declined substantially when people had moved from one location to another.

In another series of experiments using virtual environments, people first memorized a map of the larger location (a building). Then they navigated through the building. At different points people were stopped and tested for their knowledge of objects in that space. What was found was that information about objects in rooms that were passed through was less available than information about objects in other rooms. In essence, people were actively suppressing information that was more salient in the environment, but not relevant to the current task.

The key findings from this research are: (a) that the ability of people to update the knowledge when there has been a change in spatial or temporal location can disrupt thought processes, (b) it is more difficult for people to adapt to changes in the time frame, (c) people may inappropriately maintain information after a change in time period occurs, (d) walking through doorways causes forgetting, (e) passing through areas without interacting with objects renders knowledge of those objects less available, and (f) the effectiveness of thinking is directly influenced by the structure of the environment and how a person is interacting with that environment. This is important for the Army because Soldiers and units are more often required to operate in complex environments, such as cities and large buildings. An important component of improving performance in these settings is to have a clear understanding of how the structure of the operational environment influences the ability to perform more optimally, thereby providing the opportunity for developing methods of directly addressing these cognitive challenges. As such, it is recommended that Army training involve relatively complex environments that require a Soldier to monitor multiple sources of information to help develop skills needed to manage that information in relative short time periods. Moreover, augmented cognition technologies that are developed can take into account that Soldiers may need to be reminded of mission elements when there have been large transitions in the ongoing event structure.

Future research on these issues is needed to explore the range of knowledge that is affected by event transitions, their duration, and the response of people to experiences and training in circumstances where they need to manage knowledge in rapidly changing dynamic environments. For example, it is important for Soldiers to have an accurate working understanding of the larger battlefield, other than their own particular circumstances, as well as understanding their role within that larger battlefield space. The current research suggests that the updating of one's understanding of the dynamic environment may be compromised by the actual movement through it. The extent and duration of this disruption and the means of diminishing it are not known at this point. Further work would be aimed at developing a clearer understanding of this intercept between the architecture of cognition with the architecture of the world, and how this knowledge can be leveraged to improve human performance in complex environments.



## **Social Structures Affecting Army Performance**

**Contract #:** DASW01-00-K-0016  
**Institution:** The University of Maryland

**Contract Dates:** 08/17/2000 to 12/31/2004  
**PI:** David R. Segal  
**Co-PI:** Mady Wechsler Segal

**Problem(s)/Research Question(s)** – What are the social structures, social processes, and social psychological characteristics that lead young Americans to enter the armed forces, and affect their morale, satisfaction with service, performance, and retention?

**Technical Barriers** – Social structures, social processes, and social attitudes are in a constant state of dynamic change. Social institutions, such as the Army, and the people who work in them must constantly adapt to changes in their external environment and in their own organization.

**Significance/Impact for Basic Research** – Identification of important dimensions of social change and how people and organizations respond to them will contribute to more comprehensive theories of human and organizational performance.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- Army accession programs;
- Personnel retention programs;
- Organizational transformation programs; and
- Human resource management in the interest of maximizing combat performance.

### **Overview**

One of the major trends affecting modern American organizations is outsourcing: having functions necessary for organizational functioning, but not core to the mission of the organization, performed by people other than traditional organization members. This process, widely practiced by American corporations, has been increasingly adopted by the federal government, which uses contract workers who are not federal employees to perform a range of functions. Its adoption by the armed forces potentially frees a larger proportion of armed forces personnel for core military tasks. This requires consideration of the issue of what are the core military functions that must be performed by uniformed personnel.

The application of this practice to the armed forces, which have unique employment characteristics, has two major manifestations: basic civilianization, in which functions formerly performed by military personnel are now performed by civilians directly employed by the service, and true outsourcing, in which functions formerly performed by military personnel or by civilian employees of the military departments are now performed by civilians who are employees of a civilian corporation that has contracted with the service to do the work.

Both variants of civilianization put military personnel and civilian workers in shared work environments, where they may perform similar or complementary tasks but work under very different employment conditions (compensation, housing, discipline, etc.). Social comparison processes and awareness of the differences in conditions of employment, which tend



to favor the civilians, may produce feelings of relative deprivation among military personnel, which in turn may have an effect on their job satisfaction, their commitment to the organization, and their intention to remain in service. As an alternative, they may elect to leave the service at the completion of their obligation and enter the civilian labor force, potentially in the kinds of jobs, and with the conditions of employment, that they see being enjoyed by the civilians with whom they work.

Awareness of the differences in employment conditions on the part of the civilians may likewise affect their willingness to continue their employment. It is possible that the ratio of civilians to military personnel in the workplace, and the frequency or intensity of interaction, have implications for these outcomes. We have been able to identify no previous research on the social psychological consequences of military/civilian workforce integration in military units.

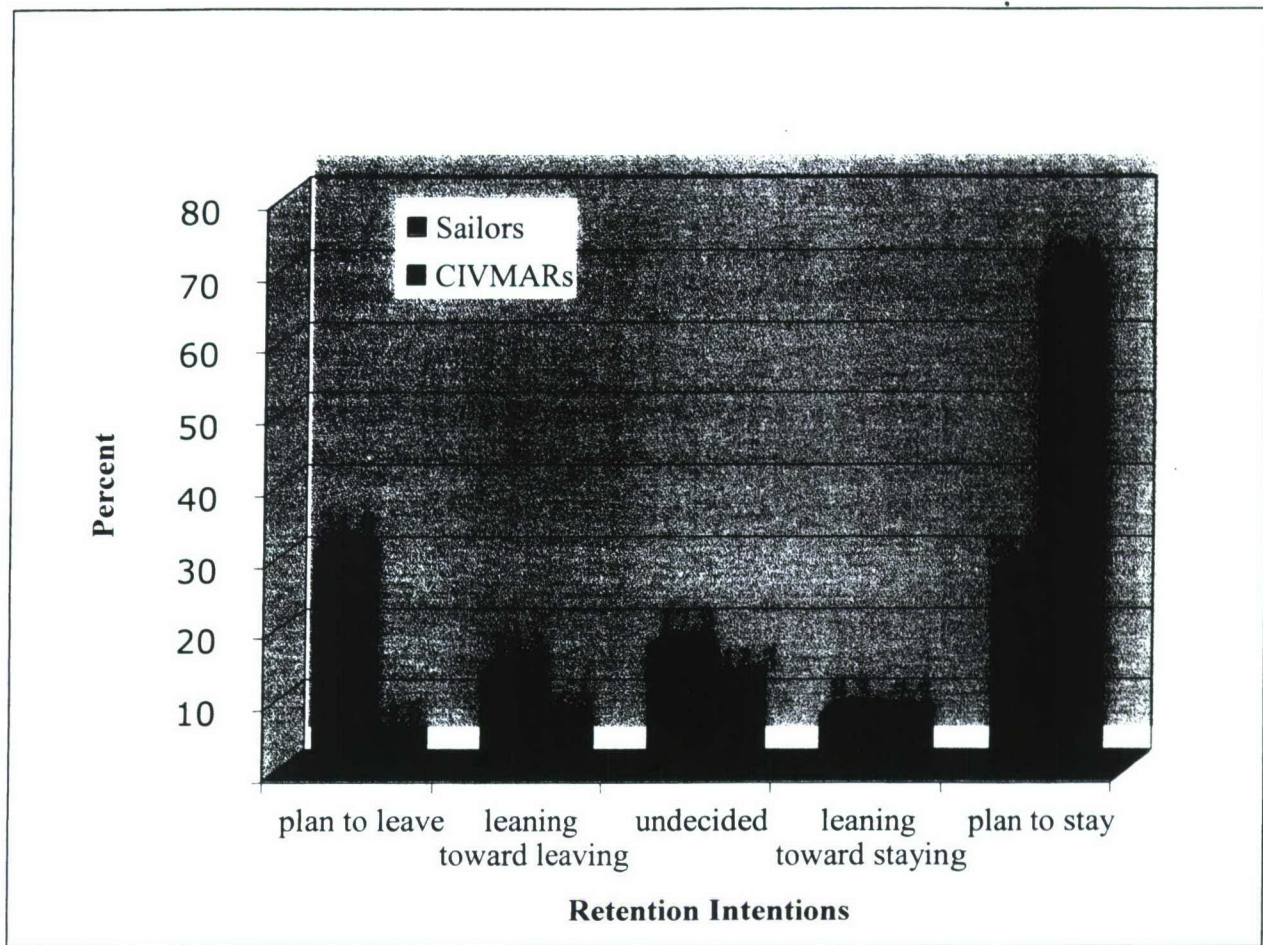
### **Research Approach**

To explore these issues, we conducted field research at two military work sites at which military personnel interact regularly with civilians who perform support functions: an Army combat aviation unit located outside the continental United States, and a Navy command and control ship in the Pacific Fleet. While in both cases the civilians were critical to the overall functioning and mission of their units, the Army and Navy incorporated their respective civilians in different ways. The civilians working on the Navy ship were federal employees, while those working with the Army aviation squadron were civilian contractors. With rare exceptions, the Army's civilian contractors had been brought in to work alongside the Soldiers, frequently performing the same tasks. By contrast, the civilian mariners with the Navy performed tasks that had been categorically civilianized, so there were no sailors performing the same duties as the civilians. We conducted surveys of the military and civilian personnel at both work sites. In addition, informal interviews were conducted with civilians and military personnel at both sites. Most of these interviews were individual one-on-one discussions, but occasionally the logistics of the situation required interviewing groups of two to five people.

### **Accomplishments**

Both our surveys and our interviews show that Soldiers and sailors in our investigation feel relatively deprived compared to the civilians with whom they work as a result of the social comparisons they make. For sailors, these feelings of relative deprivation decrease with increased levels of contact with civilians. This decrease was not observed among Soldiers. The civilians and military personnel report being satisfied with their jobs, but the civilians were significantly more satisfied than the Soldiers and sailors. The civilians were significantly more committed to their employers than the Soldiers and sailors were to the military. These sentiments had implications for people's intentions to remain in their current jobs. While at least three-quarters of the civilians at both sites leaned toward or planned to stay with their current employer, just over one-third of the armed forces personnel expressed positive intentions to remain in the military. As Figure 1 shows, on the Navy ship, 69% of the civilians and only 29% of the sailors planned to remain in their current job, while 31% of the sailors and only 5% of the civilians planned to leave. Somewhat fewer of the Army personnel and their supporting civilians were certain of their intentions, as reflected in Figure 2.





*Figure 1.* Percent frequency distribution of Sailors' and CIVMARs' retention intentions.

Social comparisons significantly and negatively impact Soldiers' and sailors' intentions to remain in military service beyond current enlistment obligations. But this effect is indirect, operating through job satisfaction and organizational commitment, which in turn affect plans to stay in the service. Social comparisons were not as important to the civilians' plans to stay in their current jobs.

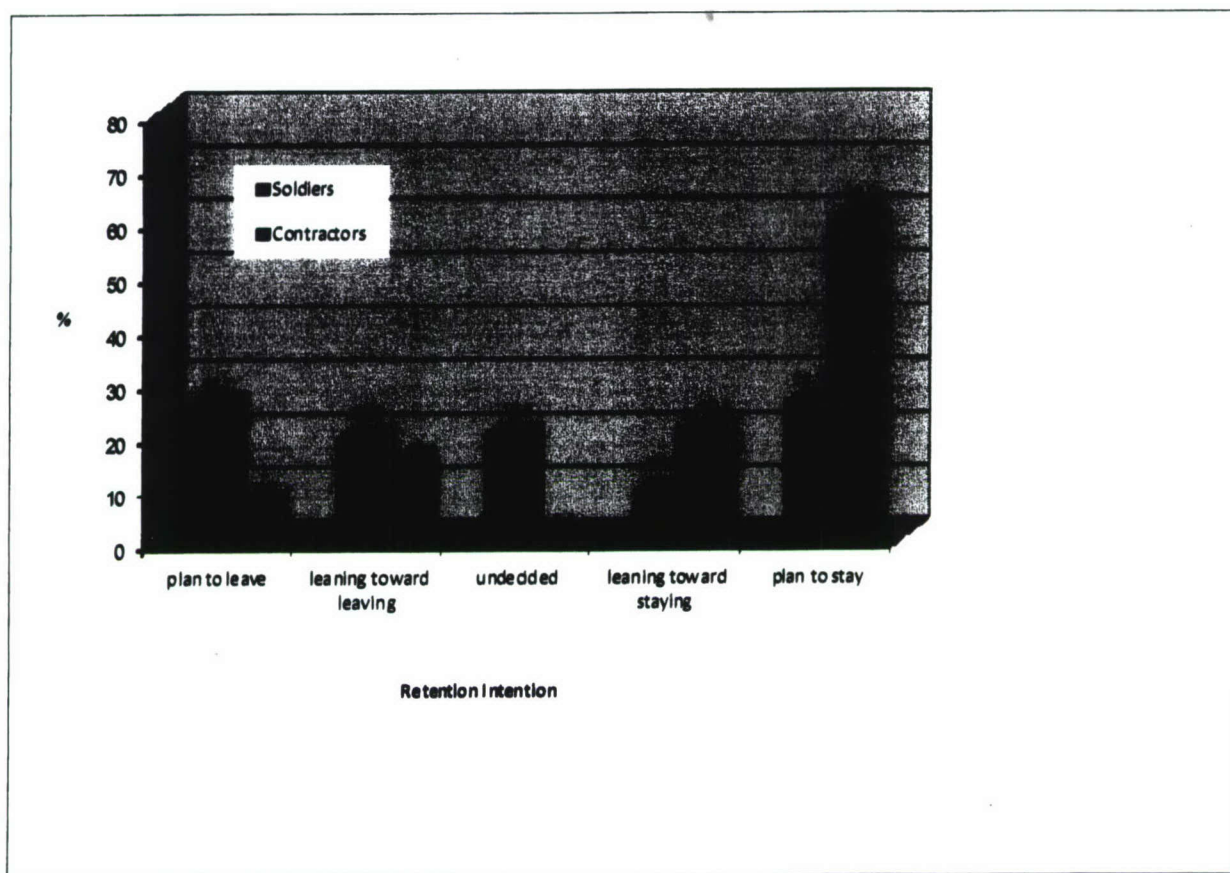


Figure 2. Percent frequency distribution of Soldiers' and civilian contractors' retention intentions.

### Contributions to Basic Research

This project provides insights into the social comparison processes that take place when people working under very different conditions of employment share a common work space. It contributes to our understanding of how feelings of relative deprivation develop, how they impact on work-related attitudes such as job satisfaction and organizational commitment, and how these, in turn, may contribute to turnover or retention in organizations. More generally, it helps us to understand how the structure of an organization affects those who work there.

### Potential Military Applications

Outsourcing has been a major trend in American industry, and a great deal of this human resource technology has been transferred to the federal government, including the Department of Defense. In the American armed forces, it has been accompanied by an ongoing civilianization of functions previously performed by military personnel, and these processes have accelerated since the advent of the Global War on Terrorism. Much of this process has focused on potential dollar savings and has taken place without regard to the social, psychological, and behavioral consequences of outsourcing and civilianization. This research gives human resource managers in the military some basis for evaluating the potential personnel costs and benefits of these processes.



## **Final Summary**

This analysis, and the broader project of which it is a part, looks at the social institutions, attitudes, and values that lead people to select different post-secondary school alternatives (military service, civilian employment, higher education), and for those who select military service, the processes that influence retention and departure. Earlier research in this program identified declines in enlistment propensity and increasing perceptions that the military discriminated on the basis of gender and race and was not a family-friendly employer. These findings presaged an actual decline in enlistment and difficulties in recruitment. The current stage of research suggests that the processes of civilianization and outsourcing may increase the difficulty of retaining people currently in the service. The combined impacts of changes in social structure and social attitudes on recruitment and retention may increase the difficulty of manning America's Army.

## **Social Structures, Social Systems, and Social Networks**

**Contract #:** W74V8H-05-K-0007

**Institution:** The University of Maryland

**Contract Dates:** 11/01/2004 to 10/31/2008

**PI:** David R. Segal

**Co-PI:** Mady Wechsler Segal & Meyer  
Kestnbaum

**Problem(s)/Research Question(s)** – Can social network theory help to understand and fight insurgencies?

**Technical Barrier(s)** – Social network theory is not highly developed; data on insurgencies are not readily available.

**Significance/Impact for Basic Research** – This attempted application of social network theory can contribute to the development of the theory of the theory and of methods of data collection.

**Potential Transitions:** Knowledge gained in this basic research may be usefully employed in:

- Army training for 21st century conflict;
- Development of doctrine for 21st century conflict;
- Assisting decision-makers in understanding 21st century conflict; and
- The general understanding of the structure of networks.

### **Overview**

The armed forces of the United States have formal and publicly known organizational structures and are trained to engage in combat with similarly structured forces of other major nations. This was the nature of most of our military engagements during the twentieth century, such as the two World Wars, and has been the basis for most of our combat doctrine. However, the conflicts in which we have been engaged more recently have increasingly involved adversaries that are not structured as we and our allies are, and our major twentieth century adversaries were. They are increasingly less likely to be acting as agents of nations, and they go to great lengths to conceal the nature of their organization. The purpose of this research is to apply a perspective known as social network theory to the understanding of the Baathist insurgency in Iraq after the fall of the Saddam Hussein regime in Operation Iraqi Freedom, to evaluate its contribution to understanding the structure of the insurgency, and to identify its potential contributions to counter-insurgency doctrine and to military operations against insurgencies. We feel that this knowledge will contribute to an understanding of twenty-first century warfare and contribute to training and doctrine with regard to these conflicts.

### **Research Approach**

The data collection phase of this research is a field study of the military operations that led to the capture of Saddam Hussein. The analysis of these data from the perspective of social network theory helps us understand which elements of the theory are useful, how the theory can be developed further, and how it can be applied in other field settings.



Our data come from the Intelligence Preparation of the Battlefield (IPB) by the 4<sup>th</sup> Infantry Division, operating in the area of Tikrit, Iraq, in 2003, and engaged in the attempt to capture Saddam Hussein, who was moving around the country. One of the elements of the IPB was the development of link diagrams, showing anyone known to be related to Saddam Hussein by blood or tribe. Additional intelligence information identified people who were not related to Saddam Hussein in these ways, but were functionally related to him, e.g., were drivers, bodyguards, or secretaries. Building the diagrams involved identifying the roles that individuals played, according to the Division's understanding of organizational functioning (e.g., chief of staff).

### **Accomplishments**

The basic structure of Saddam Hussein's network was identified in the link diagrams. Ultimately, 214 interconnected individuals were identified in the network. Figure 1 shows the basic link diagram. Note the basic links; the dimensions of this report do not allow for a full, readable diagram. The basic structure of the network was very simple. Only a small proportion of the total possible ties between individuals actually existed. The network was not very dense. Despite the fact that most of the members of the network were extended or immediate family, most people were directly connected to very few others. Thus, they were not in a position to give information on many other people if captured. The average number of steps necessary to get from one person to another was between five and six. The largest group of people in which each was connected to all others in the group was three, and there were only thirteen such three person cliques. Family relationships account for most of these three-person cliques. Only twenty-three people had direct ties to Saddam Hussein, and as Figure 2 shows, none of these people had direct ties to any of the others. Only two three-person groups are linked directly to Hussein. Other members of the network were connected to Hussein indirectly, through one or more of these twenty-three people. Most members of the network were at some considerable social distance from Saddam Hussein. Thus, Saddam Hussein was extremely insulated. A journal article reporting these findings has been published.

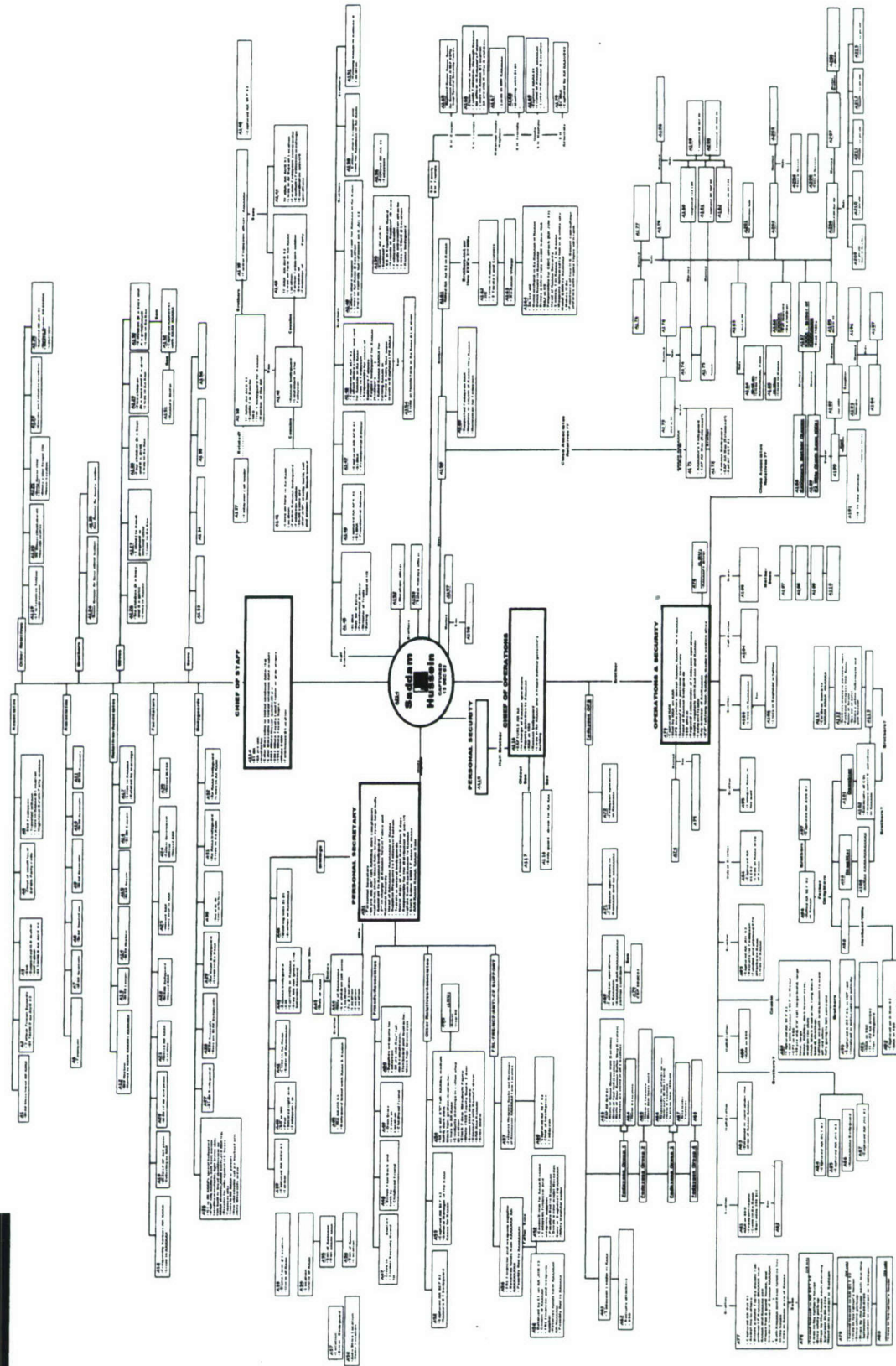


Figure 1. Full network of Saddam Hussein.



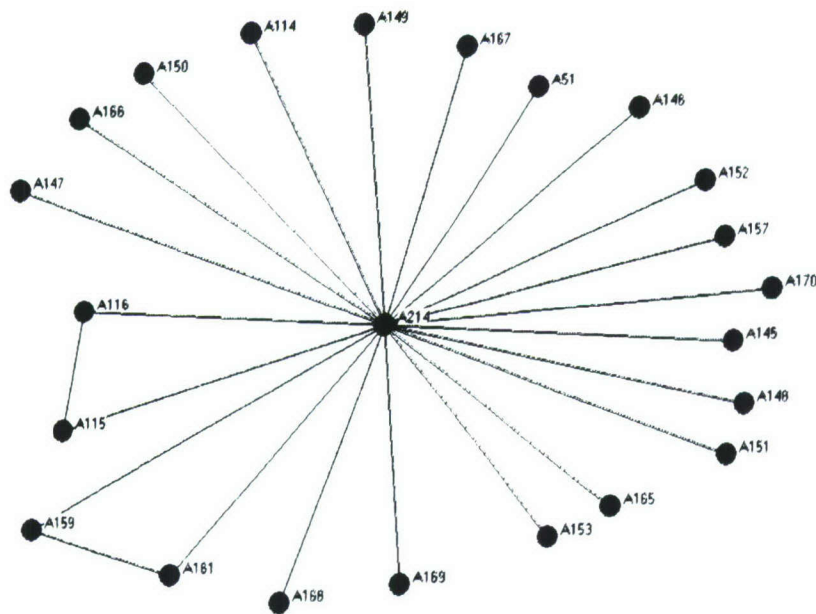


Figure 2. Saddam Hussein's sub-network.

### Contributions to Basic Research

The most dramatic contribution of this study to basic research might be the confirmation of population structure that has been demonstrated in previous and very different studies of social network structure. Stanley Milgram's "small world" experiments in the 1960s suggested that people in the United States are connected by six links, on average. More recently, Duncan Watts, in an international study, found that the average number of intermediaries needed to get an electronic communication between two people internationally was about six. While neither of these studies supports the notion of "six degrees of separation" made popular by the stage play and film of that name in the early 1990s, by the first season *Battlestar Galactica* episode with that name, or the recent television series, *Six Degrees*, they all suggest that about five points are necessary to link people, on average. In the current analysis, as Figure 3 shows, more than half of the members of the network were linked to each other by five or fewer intermediate steps, and about two thirds of the people in the network were linked within six degrees of separation. Thus, the structure of this insurgency network, while less dense, was not very different, at least in terms of interconnectedness, from other social networks that have been analyzed. With nine degrees of separation, 80% were linked. However, in Saddam Hussein's network, 20% still needed more than nine intermediary steps to be linked together. This finding contributes to our understanding of network structures.

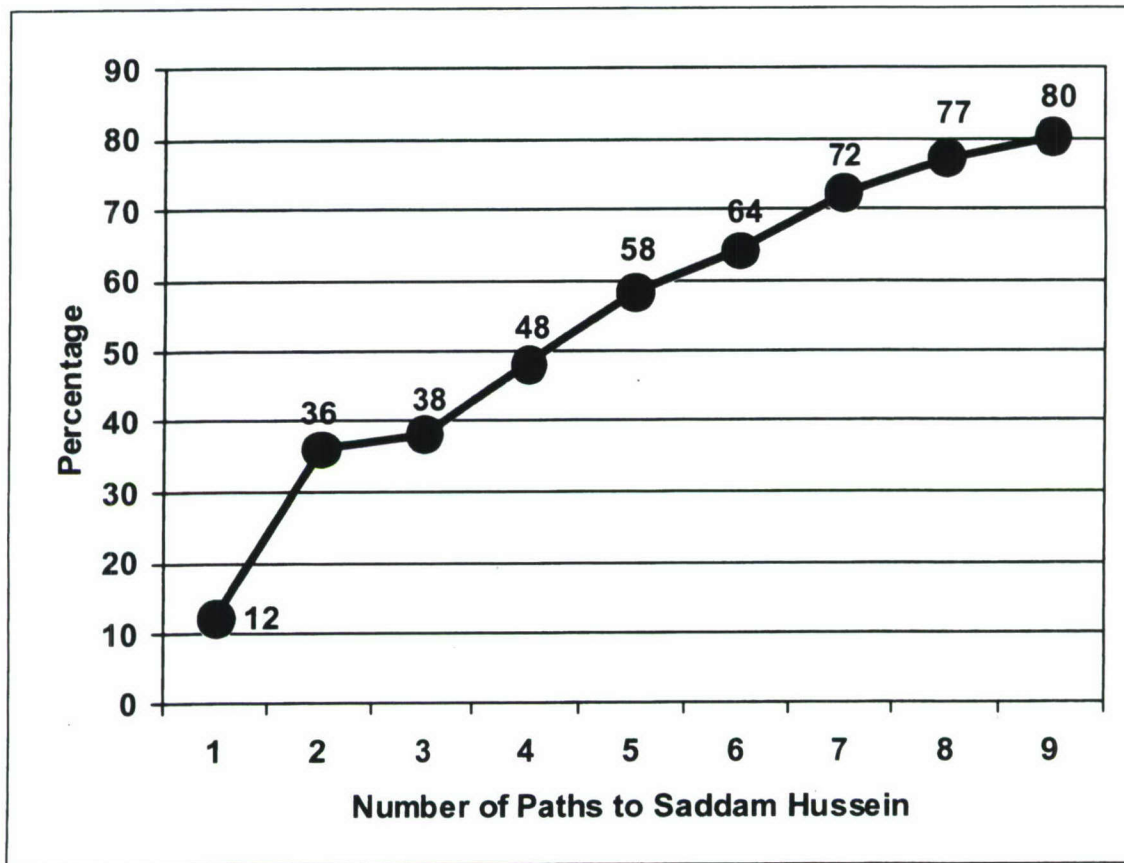


Figure 3. Number of paths to Saddam Hussein.

Equally important, it demonstrates that when organizational structure is unknown, and indeed when attempts are made to keep it from being known, the structure may nonetheless be inferred from publicly available information, such as newspapers, communications patterns such as e-mails and telephone calls, and interrogations.

### Potential Army/Military Applications

The most dramatic application is that Saddam Hussein was captured. Using the network structure, the Army staged a series of raids in November and December 2003 that first caught a number of mid-level leaders, then the inner circle, and ultimately Saddam Hussein himself. As a result of this success, an appendix on social network analysis has been included in the Army's new field manual on insurgency. Doctrine on social network analysis is being developed and Army schools, including West Point, have begun teaching techniques of social network analysis.

### Future Plans

During the next year, we will continue analysis of these network data to evaluate the utility of the various metrics that have been developed for understanding the structure of social networks.



## **Construct Validating Aspects of the Theory of Successful Intelligence via a Test Battery for Measuring Mental Flexibility**

**Contract #:** DASW0-03-K-0001  
**Institution:** Yale University

**Contract Dates:** 03/01/2003 to 03/31/2006  
**PI:** Robert J. Sternberg  
**Co-PI:** Cynthia Matthew  
**Liaisons:** Dr. Joseph Psotka, LDRU  
Dr. Peter Legree, BRU

**Problem(s)/Research Question(s)** – Mental flexibility—the ability to cope with novelty and to establish automatized levels of information processing—is an important aspect of intelligence as it is conceptualized in Sternberg’s triarchic theory of successful intelligence. The purpose of this project is to create a new assessment instrument that simultaneously provides partial construct validation of the theory of successful intelligence (Sternberg, 1985) and a means for assessing mental flexibility.

**Technical Barrier(s)** – There currently exists no broadly conceived test of mental flexibility, hence, a measure is needed that will do justice to the construct.

**Significance/Impact for Basic Research** – Given the importance of mental flexibility in a rapidly changing world, and the fact that such flexibility is not currently assessed within the framework of conventional psychometric tests, such a test seems to have practical utility as well as theoretical justification. In battlefield situations, circumstances change rapidly and commanders need to be able to change their plans quickly and effectively in response to changing conditions. For example, the shape of the conflict in Iraq changes continually, and effective response requires flexibility in recognizing the changing posture of the enemy.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- SELECT21: Selection, Classification and Performances Metrics for the Future Force (WP 257) and Selection, Classification, and Performance Metrics for the Future Force Soldier (ATO: IV.HS. 2002.01);
- LEADERSHIP: Developing Leaders in a Changing Army (WP 103);
- Accelerating Leader Development (WP 269) and ATO III.HS.2004.01;
- Future Force Warrior Training (WP 215); and
- FUTURE-TRAIN: Techniques and Tools for C4ISR Training of Future Brigade Combat Team Commanders and Staffs (WP 211).

### **Overview**

Intelligence tests have always been subject to heavy criticism. One of the most prominent criticisms regards the lack of precision in predicting success in dealing with real-life problems, such as educational or occupational. Thus, it can be questioned whether scores on traditional intelligence tests, taken alone, are optimal for predicting success in problem solving in a rapidly changing world or even whether the traditional concept of “intelligence” is wholly adequate for this purpose. An appropriate assessment procedure should reflect a person’s ability to adjust in a flexible manner to changing situational requirements.



The theory of successful intelligence specifies not only the kinds of broad abilities (analytical, creative, and practical) that play a role in achieving success, but also the cognitive processes required to apply these abilities and the problem-solving strategies through which success may be achieved. Within the framework of the triarchic theory of successful intelligence, intelligence is conceptualized on three different levels. On the first level, the focus is primarily on the interaction of cognitive components as the elementary and universal units of information processing (componential subtheory). The second level deals with the relationship of intelligence to the experience of the individual (experiential subtheory). On the third level, intelligence is defined in terms of the context in which intelligent behavior occurs (contextual subtheory). We hypothesize that Mental Flexibility will be expressed through all three levels, and are assessing Mental Flexibility in the:

- componential subtheory through tests of *Flexible Inference* and *Flexible Mapping*,
- experiential subtheory through tests of *Figural and Verbal Counterfactual Analogies*, and *Insight* problems,
- contextual subtheory through the *Flex Art* test

The goal of this project is to develop a new assessment instrument based on the theory of successful intelligence to measure mental flexibility. Mental flexibility, as we conceptualize it, is a part of creative thinking, but not the only part. Aspects of personality (e.g., openness to experience, need for cognition) and motivation (e.g., goal orientation) also contribute to creative thinking. As a sub-construct, mental flexibility manifests itself at every level of the theory of successful intelligence (componential, experiential, and contextual). Accordingly, we have created a multifaceted test of flexible thinking derived from the theory to measure how well one can apply the components of intelligence to relatively novel tasks and situations. Given the importance of flexibility in a rapidly changing world, and the fact that mental flexibility is not currently assessed within the framework of conventional psychometric tests (Sternberg, 1981), such a test seems to have practical utility as well as theoretical justification.

## **Research Approach**

Broadly speaking, the concept of successful intelligence recognizes the importance of socio-cultural context, in addition to multiple personal capabilities, in determining success. This conception stands in contrast to traditional views of intelligence, which posit a single personal capability that determines success across performance situations. Successful intelligence is the balancing of analytical, creative, and practical abilities to achieve success within a particular socio-cultural context. In other words, success within a particular socio-cultural context is determined by one's ability to capitalize on one's strengths and compensate for one's weaknesses to enact strategies for achieving success.

Mental flexibility, as we conceptualize it, is a part of creative thinking, but not the only part. Aspects of personality (e.g., openness to experience, need for cognition) and motivation (e.g., goal orientation) also contribute to creative thinking. As a sub-construct, mental flexibility manifests itself at every level of the theory of successful intelligence (componential, experiential, and contextual). Performance on a test of mental flexibility should also provide incremental prediction of success beyond that obtained with conventional, g-based tests.



Five new mental flexibility assessment instruments were developed and underwent formative and summative evaluation. An initial item pool for each mental flexibility test was first developed and reviewed. Initial tests were piloted via a combination of paper-and-pencil and computerized on-site administration to a sample of college undergraduates. The pilot data were analyzed and revised accordingly. A revised and expanded mental flexibility battery and validation measures were administered to a larger sample of college undergraduates and analyzed. This revised and expanded assessment battery contained the following five newly developed instruments:

1. *Flexible Inference*. This new test of mental flexibility is computer-administered and made up of classification problems designed to assess the ability to infer relations flexibly. It contains 18 items, in the figural, verbal, and numerical content domains. Each item contains an item prompt and a set of four domain-consistent response pair options, one of which must be linked to the prompt by inferring common properties. Each item triplet contains the same stimuli. The three parts of an item differ in the arrangement of elements in response pairs such that a common property must be inferred to link the prompt to the correct pair. To solve an item part, previously inferred relations must be inhibited and new ones identified. The inferred relation that links a prompt to the correct response pair option is classified as *domain typical* or *domain atypical*. *Domain-typical* relations are based on properties that are dominant and might typically be considered in the domain of reference. *Domain-atypical* relations are based on properties that might be secondary and would less often be considered in the domain of reference.
2. *Flexible Mapping*. This new test of mental flexibility is computer-administered and made up of 21 analogy problems designed to assess the ability to map inferred rules across figural, verbal, and numerical content domains. Each item triplet is made up of an analogy that varies in terms of the content domain to which it must be mapped. For each triplet, one part must be mapped to the same content domain (*domain homogeneous*), and two must be mapped to different content domains (*domain heterogeneous*).
3. *Counterfactual Analogies (CFA)*. This is a set of two tests of mental flexibility made up of counterfactual (novel) and familiar analogy problems drawn from Sternberg (1986) and designed to assess the ability to cope with relative novelty in the verbal and figural domains. Tests contain a mix of items, some requiring reasoning based on facts and others requiring reasoning based on counterfactual (novel) premises.
  - (a) *CFA-Verbal* is a computer-administered test that contains 48 verbal analogy items with four response options. Applying a scheme developed by Sternberg and Gastel (1989a, 1989b), all items are preceded by a premise that is either familiar or counterfactual (novel), and either relevant or irrelevant. Participants are first presented with the premise and given as long as they wish to read it. They then press a button, which results in the disappearance of the premise and the immediate appearance of the analogy item. Accuracy scores for CFA-Verbal are calculated by summing correct responses.



- (b) *CFA-Figural* is a computer-administered test that contains 30 figural analogy items with four response options. Applying a partially modified scheme of one developed by Sternberg and Gastel (1989), all items are preceded by a premise that is either familiar or counterfactual (novel). Items were equally divided among these two premise types. Participants are first presented with the premise and analogy stem, and are given as long as they wish to view it. They then press a button, which results in the disappearance of the premise and the immediate appearance of the analogy item. Accuracy scores for CFA-Figural are calculated by summing correct responses.
4. *Insight Test*. This new test of mental flexibility is a paper-and-pencil administered test of coping with novelty through insight. It contains nine insight problems drawn from the literature (Fixx, 1972; Metcalfe, 1986a; Seifert & Patalano, 1991; Sternberg & Davidson, 1982; Weisberg, 1988) that represent a mix of verbal, figural, and numerical problem types. Participants are asked to provide open-ended responses to insight problems and are given as long as they wish to complete the test. A sample problem reads as follows, "A bottle of wine costs \$10. The wine was worth \$9 more than the bottle. How much was the wine worth?" (Sternberg & Davidson, 1982).

In order to validate the newly developed assessments described above, we also administered:

- Two tests of **cognitive ability**: (1) the *Berlin Model of Intelligence Structure* (BIS: Jager, 1982, 1984), and (2) the *French Kit of Factor-Referenced Cognitive Tests* (F-Kit: Ekstrom, French, Harmon, 1976). The BIS is a bimodal hierarchical model for describing broad intellectual abilities in the framework of four operational components (processing speed, memory, creativity, and processing capacity) and three content-based components (figural, verbal, numerical), which are composed of 12 facets of performance. The French kit is a battery made up of a set of 72 marker tests for 23 cognitive aptitude factors. Two subtests (Letter Sets Test –I-1 [rev.], Locations Test –I-2) of three that comprise the induction factor (convergent) were administered.
- Four tests of **pattern recognition**: (1) *Soluble/Insoluble Analogy Test*. This is a 30-item multiple-choice figural analogy test developed for this investigation. It is designed to measure pattern recognition by comparing response accuracy on soluble versus insoluble items; (2) *Group Embedded Figures Test* (GEFT; Witkin, Oltman, Raskin, & Karp, 1971, 2002). This test is an adaptation of the Embedded Figures Test (EFT; Witkin, 1950; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962) modified for group administration. It measures competence in perceptual field independence, which has been associated with a global-versus-analytical dimension of cognitive functioning; (3) *Revised Minnesota Paper Form Board Test* (Likert & Quasha, 1970; Paterson, Elliott, Anderson, Toops, & Heidbreder, 1930). This test measures the capacity to visualize and manipulate objects in space; and (4) *Minnesota Clerical Test* (Andrew & Paterson, 1959). This is a test of perceptual speed and accuracy in recognizing name and number sequence pairs.



- Two **personality tests**: (1) the *Cognitive Flexibility Scale* (Martin & Rubin, 1995). This self-report survey measures three components of cognitive flexibility including: (a) awareness of available options and alternatives; (b) willingness to be flexible and adapt to situations, and (c) self-efficacy in being flexible; and (2) the *NEO-Personality Inventory Revised* (Costa & McCrae, 1992). This personality survey measures five dimensions including: neuroticism, extroversion, openness, agreeableness, and conscientiousness.

## **Accomplishments**

We completed a summative evaluation of the new assessment instruments on a sample of 476 college students. The newly developed mental flexibility tests showed adequate reliability, and preliminary evidence of construct- and criterion-related validity as measures of the ability to cope with novelty. One mental flexibility factor explained 70% of variance in the test battery and was differentiated from the latent factor underlying divergent and convergent measures of fluid intelligence. Preliminary evidence of incremental criterion-related validity was found, suggesting that the mental flexibility test battery explains variance above and beyond divergent and convergent measures of fluid intelligence in criterion measures. Newly developed mental flexibility tests showed a consistent and strong pattern of association with measures of pattern recognition, suggesting it may be an important predictor of mental flexibility.

## **Contributions to Basic Research**

According to the theoretical assumptions within the framework of the theory of successful intelligence, mental flexibility reflects the ability to deal with novelty and to establish automatized levels of information processing. To assess this ability we utilized an assessment approach that belongs to the category of dynamic testing. As has been shown in other areas (e.g., for the assessment of learning ability, see Guthke & Beckmann, 2000, 2003; see also Sternberg & Grigorenko, 2002), this diagnostic approach represents a more appropriate way to assess intellectual abilities such as mental flexibility. In contrast to traditional approaches, the focus here is on a person's ability to deal with standardized variations of test conditions. In addition to this methodological improvement, the investigation will provide further insight into the cognitive processes underlying intelligent behavior while adapting to, shaping, and selecting an environment in novel situations. Furthermore, we may gain another piece of evidence for the validity of the theory of successful intelligence with its broader and therefore better applicable conceptualization of intelligence.

## **Potential Army/Military Applications**

Findings suggest that the newly developed test battery may measure flexible cognitive ability outside the framework used by conventional tests of fluid intelligence, supporting the validity of the experiential subtheory of successful intelligence. The mental flexibility test battery developed for purposes of this investigation represents an initial stage in the development of a test battery that could potentially be used for selection and placement in educational and occupational settings. Given the importance of mental flexibility in a rapidly changing world, and the fact that it is not currently assessed within the framework of conventional psychometric tests, these tests seem to have practical utility as well as theoretical justification.



## **Final Summary**

The goal of this project was to develop and evaluate a test battery that assesses mental flexibility based on the theory of successful intelligence (Sternberg, 1985). Mental flexibility is defined as the ability to cope with novelty and establish automatized levels of information processing. This research simultaneously provides a means for assessing mental flexibility and validating the experiential subtheory of the theory of successful intelligence.

Five new mental flexibility assessment instruments were developed and underwent formative and summative evaluation. An initial item pool for each mental flexibility test was first developed and reviewed. Initial tests were piloted via a combination of paper-and-pencil and computerized on-site administration to a sample of college undergraduates. The pilot data were analyzed and revised accordingly. A revised and expanded mental flexibility battery and validation measures were administered to a larger sample of college undergraduates and analyzed.

The newly developed mental flexibility tests showed adequate reliability, and preliminary evidence of construct- and criterion-related validity as measures of the ability to cope with novelty. One mental flexibility factor explained 70% of variance in the test battery and was differentiated from the latent factor underlying divergent and convergent measures of fluid intelligence. Preliminary evidence of incremental criterion-related validity was found, suggesting that the mental flexibility test battery explains variance above and beyond divergent and convergent measures of fluid intelligence in criterion measures. Newly developed mental flexibility tests showed a consistent and strong pattern of association with measures of pattern recognition, suggesting it may be an important predictor of mental flexibility.

Findings suggest that the newly developed test battery may measure flexible cognitive ability outside the framework used by conventional tests of fluid intelligence, supporting the validity of the experiential subtheory of successful intelligence. The mental flexibility test battery developed for purposes of this study represents an initial stage in the development of a test battery that could potentially be used for selection and placement in educational and occupational settings. Given the importance of mental flexibility in a rapidly changing world, and the fact that it is not currently assessed within the framework of conventional psychometric tests, these tests seem to have practical utility as well as theoretical justification.



## **Temporal Investigations Into the Relationships Between Affect and Discretionary Work Behaviors**

**Contract #:** W74V8H-04-K-0001  
**Institution:** Purdue University

**Contract Dates:** 05/01/2004 to 12/31/2006  
**PI:** Howard M. Weiss  
**Co-PI:** Reeshad S. Dalal  
**Liaisons:** Michelle Zbylut, LDRU  
Mike Rumsey, SARU

**Problem(s)/Research Question(s)** – What is the nature of the structure of citizenship and counterproductive work behavior (collectively known as discretionary behavior)? How does discretionary behavior vary over time within individuals, and does its expression vary as a function of changes in persons' affective (emotional) states? Also, what are some of the variables that would alter the relationship between emotions and discretionary behavior at work (e.g., leadership, climates)?

**Technical Barrier(s)** – Models of how discretionary behavior changes within individuals, and the effects of emotions on discretionary behavior, have not been well developed. This lacuna existed in large part because the methodological and statistical tools to study such phenomena have not existed until recently.

**Significance/Impact for Basic Research** – Understanding the structure of discretionary behavior, and the emotion-behavior linkages, will lead to more comprehensive theory and models of human performance.

**Potential Transitions** – Knowledge gained in this basic research may be usefully employed in:

- WP 215 — Objective Force Warrior Training
- WP 269 — Accelerating Leader Development;
- WP 283 — Validating Future Force Performance Measures; and
- WP 302 — Ground Systems Team Training.

### **Overview**

In spite of the recent interest in citizenship and counterproductive work behavior (collectively called discretionary work behavior), and their documented importance to organizational functioning, much remains to be discovered about these criteria. Our program of research integrates the burgeoning literature on the immediate consequences of momentary affective states (see Brief & Weiss, 2002, for a review of this literature) with the literature on discretionary work behavior. We are conducting several studies that explore and map individuals' naturally-occurring on-the-job citizenship and counterproductive behavior, the emotional antecedents of such behavior, and the variables that potentially influence emotion-behavior relationships (e.g., leadership, climates). In order to better understand the emotional causes of citizenship and counterproductive behavior, we first have to understand the underlying dimensional structures of this behavior.



There are four main goals of our project. First, we are examining the structure of work behavior by determining their co-occurrence and switching over time. The main aims of this study are to determine which behaviors occur together on a given time occasion (i.e., behavioral co-occurrence) and to predict changes from one behavioral state on one occasion to the next behavioral state on a subsequent occasion (i.e., behavioral switching). So far, the literature has not examined the possibility that the dynamic structure (i.e., using “time” as the level of analysis) of citizenship and counterproductive behavior may not mirror the static structure (i.e., using “person” as the level of analysis)—an oversight that needs to be rectified. The structure of discretionary behavior also needs to be established before we explore its emotional antecedents.

The second study focuses on establishing employees’ immediate emotional states as the causes of citizenship and counterproductive work behavior. Research examining the impact of emotional states on citizenship behavior and, particularly, counterproductive behavior is rather meager. Even less understood are the work events that instigate the immediate emotional states and thereby drive the display of this behavior. Although the basic research on emotions suggests that momentary affective states are an important influence on both citizenship behavior and counterproductive behavior, a thorough and overarching framework for studying these relationships in detail is needed. We use Affective Events Theory (Weiss & Cropanzano, 1996) as a unifying framework for understanding these relationships in detail. A fundamental proposition of our research is that changes in the likelihood of engaging in citizenship and counterproductive behavior over time are related to changes in a person’s affective states. Therefore, in order to test our predictions, we will examine how behavior and emotions change within people over time rather than between people. This approach, known as a within-person design, will allow us to study how key events in the workplace, and the way supervisors and organizations create and manage these events, influence employees’ behavior and affective states.

The experience of negative affective states does not always lead to dysfunctional work behavior; similarly, citizenship behavior does not always follow positive affective states. People’s ability to “influence which emotions they have, when they have them, and how they experience and express those emotions” should influence whether or not a given behavior is exhibited (Gross, 1999, p. 557). This process, known as emotional regulation, must be integrated into the study of the way emotional states instigate counterproductive behavior. Individuals vary in their ability to regulate their emotions, but situational constraints may also determine whether individuals have the ability to regulate and control their emotions. It is likely that the ability to regulate one’s emotions (or lack thereof) will influence the expression of counterproductive and citizenship behavior. By investigating the role of emotional regulation, researchers will ultimately be able to develop taxonomies of stable regulatory strategies that can be used to control the dysfunctional consequences of emotional states.

Employees’ emotions and behavior occur in a work context that can play an important role in facilitating or inhibiting certain behaviors following an emotion-instigating event. Therefore, the fourth study examines leaders’ ability to regulate their subordinates’ behavior via the creation of “climates,” leaders’ adeptness at identifying others’ emotions, and their skill at managing and altering these emotions in an effort to avert counterproductive behavior on the part of the employee.



## **Research Approach**

Contrary to traditional cross-sectional studies that look at differences in key variables between individuals, we adopt a within-person approach that examines how variables change within an individual over time. Given that the structure of discretionary behavior and the associations between affect and such behavior are likely to be temporally sensitive, we use a dynamic data collection tool known as Ecological Momentary Assessment (EMA). Ecological momentary assessment has, of late, begun to gain popularity in the organizational psychology literature (Weiss, Nicholas, & Daus, 1999; Alliger & Williams, 1993) because it allows for the quantitative analysis of work behavior in its natural context (Hormuth, 1986)—not only its natural physical context but also its natural temporal context. EMA can therefore be used to examine issues concerning the relatedness of variables within persons over time.

In order to capture events as they occur, we will be asking participants to complete multiple daily questionnaires on Personal Digital Assistants (PDAs), such as Palm Pilots™, for data collection. Because people cannot be constantly surveyed, several different EMA sampling strategies have been developed. Participants can be surveyed upon the occurrence of specified events, or a fixed or random amount of time after the previous survey. The durations of the studies vary as a function of the particular samples used and the research questions of interest; however, studies will typically last 10-15 working days. Individuals will be asked to provide reports of their discretionary behavior and affective states several times per day.

## **Accomplishments**

We have completed data collection on all four studies. Study 1 was presented at the 2006 annual meeting of the Society for Industrial and Organizational Psychology, as part of a symposium on innovative methodological research on citizenship and counterproductive work behavior. Subsequently, Study 1 was submitted to the *Academy of Management Journal* (one of the premier outlets for I/O psychology research). We received a “revise-and-resubmit,” and are currently in the process of revising the paper. Study 2 and the pilot data from Study 4 have been submitted for consideration at the 2007 annual meeting of the Society for Industrial and Organizational Psychology. Both submissions were accepted. We are currently analyzing the data from Study 3 and have just completed the data collection on Study 4. We also have one technical report under review at ARI, and are in the process of preparing two additional reports.

## **Contributions to Basic Science**

Contrary to most traditional models of work performance, our focus on employees' affective states as predictors of performance extends the existing literature by providing a framework for understanding how emotions influence discretionary work behavior over time. In addition, our projects integrate theories of affective experiences, emotional regulation, and discretionary work behavior. In addition to these theoretical contributions, our findings will provide the basis for developing interventions for preventing dysfunctional work behavior through the use of emotional regulatory strategies. Employees may be trained to recognize the interplay between their emotions and performance at work, and supervisors and organizations



can develop work environments that would foster affective states that lead to citizenship behavior and discourage counterproductive behavior through the reduction of negative affective states.

### **Potential Army/Military Applications**

Negligent and willful counterproductive/deviant behaviors are especially of great importance in the military, where the cost of such behavior during combat operations can often be measured in terms of lost lives: those of civilians, of one's fellow Soldiers, and—in cases of excessive brutality and wanton disregard for norms of civilized combat—even of enemy combatants and detainees. Consequently, it is no great surprise that the United States military has long recognized the importance of studying counterproductive (also called deviant or delinquent) behavior among its own Soldiers (e.g., Bell & Holz, 1975; Lennon, 1994). Our research is unmistakably relevant to the U.S. Army in its quest for the “good Soldier.” Clear implications for training interventions and further applied research in Army settings can be drawn from this research.

The major implication of our research is that behavior and emotions are transient in nature. They may therefore have a dynamic, temporal structure that is not identical to their static structure. We suggest first determining the temporal structure of discretionary behavior in civilian settings with their inherent lower-intensity stressors, and then conducting more applied research with the military to examine the extent to which previous findings hold up in more extreme situations—e.g., patterns of Soldier behavior under (simulated) enemy fire on the battlefield. This subsequent applied military research can take the form not only of analysis of emotion-behavior and behavior-behavior links in simulated real-time battlefield environments, but also of retrospective investigations into egregious incidents committed by Soldiers (e.g., torturing prisoners, executing civilians, shooting their own colleagues, committing mutiny against superior officers, etc.). Such research would provide valuable “red flags” that, if heeded, could head off extremely serious incidents before they actually occur.

Another implication of our proposed research is that emotional responses to stressful and/or aversive events can be regulated, preventing expression of counterproductive behavior. Emotional regulation strategies can be executed either by the Soldier himself or herself, or by the commanding officer. Research on emotion-behavior links and emotional regulation are perhaps even more important in the military than in other settings, given research suggesting that verbal behavior in the military has ambiguous emotional nuances, making correct interpretations of the speaker's intent especially difficult (Wirshbo, 1990). Officers unable to correctly discern their subordinates' emotional states are unlikely to be able to respond with appropriate emotional regulation strategies. Future research in military settings should therefore examine situational and individual differences in emotional judgment related to oneself or others.

Additionally, our research can lay the groundwork for the study of officer-sponsored “climates” that create contingencies between certain behavior and certain outcomes, thereby attenuating emotion-behavior linkages. For instance, an officer who clearly articulates and consistently enforces a policy of sanctions for poor disciplinary practices may be able to reduce the incidence of such practices regardless of the frequency and magnitude of stressors and



consequent aversive reactions experienced by his or her subordinates. The findings of our studies are likely to provide material relevant to courses in leader development and training.

### **Future Plans**

We received a “revise-and-resubmit” on a paper based on Study 1 that we submitted to the *Academy of Management Journal*. We have recently resubmitted this paper, and are awaiting the journal’s response. Moreover, in May 2007, we will be presenting results from Study 2 and the pilot data from Study 4 at the Society for Industrial and Organizational Psychology’s annual meeting. Over the remainder of the year, we plan to submit these findings for publication, and also to complete analyzing and writing up the results of Study 3. Moreover, we are in the process of preparing our second and third technical reports for ARI.